DRAFT

National Education Policy – 2020

Common Minimum Syllabus for State Universities and Colleges of Uttarakhand

Four Year Undergraduate Programme- FYUP/Honours Programme/ Master's in Science

PROPOSED STRUCTURE FOR FYUP/ MASTER'S IN ZOOLOGY SYLLABUS

DEPARTMENT OF ZOOLOGY

Syllabus Expert Committee

S.No.	Name	Designation	Department	Affiliation
1.	Prof. H.C.S. Bisht	Head and Convener	Department of Zoology	Kumaun University, Nainital
2.	Prof. D.M.Tripathi	Head and Convener	Department of Zoology	S.D.S. University, Rishikesh
3.	Prof. Ila Bisht	Head and Convener	Department of Zoology	S.S.J. University, Almora
4.	Dr. Neeti Pande	Assistant Professor (External Subject Expert)	Department of Zoology	University of Delhi

Syllabus Preparation Committee

S.No.	Name	Designation	Department	Affiliation
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2.	Dr. Manoj K. Arya	Associate Professor	Department of Zoology	Kumaun University, Nainital
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4.	Dr. Sandeep Kumar	Associate Professor	Department of Zoology	S.S.J. University, Almora
5.	Dr. Mukesh Samant	Assistant Professor	Department of Zoology	S.S.J. University, Almora
6.	Dr. Himanshu P. Lohani	Assistant Professor	Department of Zoology	Kumaun University, Nainital
7.	Dr. Deepak K. Arya	Assistant Professor	Department of Zoology	Kumaun University, Nainital
8.	Dr. Divya Pangtey	Assistant Professor (Guest)	Department of Zoology	Kumaun University, Nainital
9.	Dr. Netra Pal Sharma	Assistant Professor (Guest)	Department of Zoology	Kumaun University, Nainital
10.	Dr. Sandeep D. Maindoli	Assistant Professor (Guest)	Department of Zoology	Kumaun University, Nainital
11.	Dr. Uzma Siddiqui	Assistant Professor	Department of Zoology	Kumaun University, Nainital

		(Guest)		
12.	Dr. Seeta Dewali	Assistant Professor (Guest)	Department of Zoology	Kumaun University, Nainital
13.	Dr. Deepak Chandra Melkani	Tutor cum Demonstrator	Department of Zoology	Kumaun University, Nainital

List of Papers (DSC,DSE,GE) with Semester Wise Titles for Zoology					
Year	**Semester**	**Course**	**Paper Title**	**Theory/ Practical**	**Credits**
UNDERGRADUATE CERTIFICATE IN ZOOLOGY					
BACHELOR OF ZOOLOGY WITH HONOURS					
	VII	(DSC)- **ZOO/DSC/VII/T**	Biology of Non- Chordata	Theory	3
		(DSC)- **ZOO/DSC/VII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE1)- **ZOO/DSE1/VII/T**	Evolutionary Biology/Elementary Ichthyology	Theory	3
		(DSE1)- **ZOO/DSE1/VII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE2)- **ZOO/DSE2/VII/T**	Animal Ecology/ Elementary Entomology	Theory	3
		(DSE2)- **ZOO/DSE2/VII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE3)- **ZOO/DSE3/VII/T**	Elementary Bio-technology/ Elementary Immunology	Theory	3

FOURTH YEAR		(DSE3)- **ZOO/DSE3/VII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(GE1) - **ZOO/GE1/VII**	Bioinstrumentation	Theory	3
		(GE2) - **ZOO/GE2/VII**	Histology	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship OR Excursion/Field study	Theory/ Practical	6
	VIII	(DSC) - **ZOO/DSC/VIII/T**	Biology of Chordata	Theory	3
		(DSC) - **ZOO/DSC/VIII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE1) - **ZOO/DSE1/VIII/T**	Ethology/Research Methodology	Theory	3
		(DSE1) - **ZOO/DSE1/VIII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE2) - **ZOO/DSE2/VIII/T**	Cytology/Biotechniques	Theory	3
		(DSE2) - **ZOO/DSE2/VIII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE3) - **ZOO/DSE3/VIII/T**	Advance Genetics/Biomedical Technologies	Theory	3
		(DSE3) - **ZOO/DSE3/VIII/P**	Laboratory Practical based on Theory Papers	Practical	1
		(GE1) -	General Biotechnology	Theory	4

		ZOO/GE1/VIII			
		(GE2) - **ZOO/GE2/VIII**	Parasitology	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship OR Excursion/Field study	Theory/ Practical	6
MASTER'S IN ZOOLOGY					
FIFTH YEAR	IX	(DSC) - **ZOO/DSC/IX/T**	Ichthyology-IA (General Ichthyology)	Theory	3
			Entomology-IB (Systematics and Applied Entomology)		
			Animal Biotechnology-IC (General Animal Biotechnology)		
			Immunology-ID(Fundamentals of Immunology)		
		(DSC) - **ZOO/DSC/IX/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE1) - **ZOO/DSE1/IX/T**	Mammalian Endocrinology/Reproductive Health	Theory	3
		(DSE1) - **ZOO/DSE1/IX/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE2) - **ZOO/DSE2/IX/T**	Developmental Biology/Avian Diversityand Behavior	Theory	3

		(DSE2) - **ZOO/DSE2/IX/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE3) - **ZOO/DSE3/IX/T**	Basic Limnology/Aquatic Diversity	Theory	3
		(DSE3) - **ZOO/DSE3/IX/P**	Laboratory Practical based on Theory Papers	Practical	1
		(GE1) - **ZOO/GE1/IX**	Computational Biology	Theory	4
		(GE2) - **ZOO/GE2/IX**	Medical Laboratory Technology	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship OR Excursion/Field study	Theory/ Practical	6
	X	(DSC) - **ZOO/DSC/X/T**	Ichthyology-II A (Applied Ichthyology)	Theory	3
			Entomology-II B (Biology of Insects)		
			Animal Biotechnology-II C (Applied Animal Biotechnology)/		
			Immunology-II D (Applied Immunology)		
		(DSC) - **ZOO/DSC/X/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE1) - **ZOO/DSE1/X/T**	Human Physiology/Osteology	Theory	3
		(DSE1) - **ZOO/DSE1/X/P**	Laboratory Practical based on Theory Papers	Practical	1

		(DSE2) - **ZOO/DSE2/X/T**	Biochemistry/Metabolism of Biomolecules	Theory	3
		(DSE2) - **ZOO/DSE2/X/P**	Laboratory Practical based on Theory Papers	Practical	1
		(DSE3) - **ZOO/DSE3/X/T**	Molecular Biology/Aquaculture	Theory	3
		(DSE3) - **ZOO/DSE3/X/P**	Laboratory Practical based on Theory Papers	Practical	1
		(GE1) – **ZOO/GE1/X**	Hydro Ecology	Theory	4
		(GE2) – **ZOO/GE2/X**	Conservation Biology	Theory	4
		DISSERTATION	Dissertation on Major OR Dissertation on Minor OR Academic Project/Entrepreneurship OR Excursion/Field study	Theory/ Practical	6

Course Objectives (COs):

- The programme in Zoology aims to provide students with a strong foundation Core course in organismal and molecular biology,

covering Non-chordata, Chordata, Cell Biology, Genetics and Physiology.

- It equips students with applied knowledge in Aquaculture, Reproductive Health, Animal Behavior, Immunology, Environmental Biology, Limnology, Microbiology and Biotechnology.
- The curriculum is designed to enable students to specialize in key disciplines such as Taxonomy, Ichthyology, Entomology, Conservation Biology and Toxicology through elective courses.
- The programme fosters interdisciplinary learning by offering generic electives in Computational Biology, Medical Laboratory Technology, Hydro Ecology and Research Methodology, attracting students from allied sciences.
- Practical-based skill development is emphasized through laboratory training in bioinstrumentation, histology, hematological techniques and immunodiagnostics.
- The course also integrates contemporary research trends such as Molecular Biology, Biomedical Technologies and Biofloc Fish Culture to develop industry-relevant expertise.
- It encourages students to engage in research and academic projects through dissertations, fostering analytical and problem-solving skills.
- Students will be equipped to address societal challenges, including environmental sustainability, wildlife conservation, public health and bioremediation.
- The programme ensures career readiness by offering skill-enhancement courses in areas like Pearl Culture, Sericulture, Vermiculture and Applied Zoology.
- Specialization such as Ichthyology, Entomology, Animal Biotechnology and Immunology gives an immense platform to pursue higher carrier opportunities.
- Graduates and Post graduates will have ample opportunities in education, healthcare, environmental management and biological

research, with the potential to pursue advanced studies and innovative entrepreneurship.

Programme Objectives (POs):

- To develop a comprehensive understanding of biological diversity, structure and function across various animal taxa.
- To provide in-depth knowledge of cellular and genetic mechanisms governing life processes, preparing students for advanced research and applications.
- To foster an appreciation for evolutionary biology and animal ecology, emphasizing biodiversity conservation and sustainable practices.
- To equip students with expertise in applied sciences, including medical laboratory techniques, immunology and aquaculture.
- To enhance analytical and technical skills through practical training in molecular biology, cytology and bioinstrumentation.
- To instill research acumen through structured dissertations and academic projects in emerging areas of Zoology.
- To introduce students to interdisciplinary domains such as Environmental Biology, Toxicology and Computational Biology for holistic scientific learning.
- To promote entrepreneurial skills and job readiness through value-added courses in Intellectual Property Rights, Research Ethics and Emotional Intelligence.
- To enable students to critically assess biological challenges and contribute innovative solutions in health, agriculture and environmental sectors.
- To prepare students for diverse career opportunities, including academia, government organizations, conservation agencies and biotechnology industries.

SEMESTER- VII

BACHELOR OF ZOOLOGY WITH HONOURS

DISCIPLINE SPECIFIC COURSE (DSC) – Biology of Non- Chordata

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSC: Biology of Non-Chordata	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor Of Zoology With Honours	**Year: IV**	**Semester: VII** **Paper: DSC**
Subject: Zoology		
Course: DSC	**Course Title: Biology of Non- Chordata**	
Course Outcomes: After studying this course, the students will be able to:		

1. Understand the biology and systematic features of non-chordates, including their body organization and adaptive features. 2. Understand the evolutionary relationships and identification of species. 3. Understand the diversity, organization, adaptation and taxonomic status of chordates. 4. Understand the basic concepts of biosystematics and taxonomy procedures. 5. Understand the types and origin of reproductive isolation and taxonomic characters.		
Credits:4		**Discipline Specific Course**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	General classification, characters, habits and habitats of Non-chordates Protozoa: Nutrition, Locomotion (Amoeboid, Flagellar and Ciliary movements) and reproduction in protozoa; Life-cycle of *Trypanosoma, Entameoba histolytica, Giardia* and *Leishmania*. Porifera: Canal system and phylogeny. Reproduction in Porifera.	**15**
Unit II	Coelenterata: Polymorphism in Coelenterata. Structure and affinities of Ctenophora, Coral and coral reefs. Helminthes: Life cycle of *Taenia solium, Fasciola hepatica, Wuchereria* and *Schistosoma.* Parasitic adaptations in helminths. Minor phyla: Rotifera and Brachiopoda: Organization and affinities.	**15**
Unit III	Annelida: Segmental organs in Annelida and Adaptive radiations in Polychaeta. Arthropoda: Larval forms in Crustacea. Mouth parts in insects. Social	**15**

	life in honeybees and termites. Onychophora: Organization and affinities. Mollusca: Torsion in Mollusca. Pearl formation and its commercial importance, respiratory and reproduction in Mollusca. Echinodermata: Water vascular system and larval forms Mechanism of Osmoregulation in invertebrate.	
Practical		
	1. Study of living animals: *Amoeba, paramecium, Euglena, Hydra*, and rectal ciliates 2. Study of Nervous-system/General anatomy with the help of charts/models and simulation of Earthworm, Prawn, *Pila, Unio*. 3. Study of permanent slides/museum specimens/models belonging to following phyla Protozoa, Porifera, Coelenterata, Helminthes, Annelida, Arthropoda, Mollusca and Echiodermata. 4. Study of Parasites: Protozoa: *Plasmodium, Moncystis, Trypanosoma, Leishmania, Entamoeba, Giardia*. Helminthes: *Fasciola, Taenia, Ascaris, Schistosoma* and filarial including larval stages. Annelida: Leeches Arthropoda: Sacculina, lice, flea, bedbug, tick and mites. Life Cycle of the following:- *Entamoeba, T. solium, A. lumbricoides, F. hepatica, Schistosoma*	**30**

Recommended Readings

Textbooks

- Modern textbook of Zoology- R. L. Kotpal,
- Invertebrate Zoology- Anderson, Donald Thomas
- Textbook of Zoology Invertebrates – Parker and Haswell
- CNH Series, Kotpal Series, Hyman Series
- Invertebrates- Brown, A. Frank
- Invertebrate Zoology- E. L. Jordan and P. S. Verma
- Invertebrate Zoology- E. E. Ruppert and R. D. Barnes

Reference Book

- The Invertebrates. 6th ed. Barnes RD. Philadelphia: Saunders College Publishing; 1982.
- Principles of Invertebrate Paleontology. 2nd ed. Shrock RR, Twenhofel WH. New Delhi: CBS Publishers.
- Textbook of Invertebrate Zoology. 1st ed. Kapoor V. Meerut: Rastogi Publications; 2013.
- Invertebrate Structure and Function. 1st ed. Barrington EJW. London: Thomas Nelson and Sons.
- The Lower Metazoa: Comparative Biology and Phylogeny. 1st ed. Dougherty EC. Berkeley, CA: University of California Press.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Evolutionary Biology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		

DSE: Evolutionary Biology	4	4	0	0	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY			
Programme: Bachelor Of Zoology		**Year: IV**	**Semester: VII** **Paper: DSE**
Subject: Zoology			
Course: DSE	**Course Title: Evolutionary Biology**		
Course Outcomes: After studying this course, the students will be able to: 1. Explain important processes, principles and concepts and evaluate theories and research. 2. Apply evolutionary theory and concepts to address questions in evolutionary biology. 3. Independently investigate evolutionary questions using literature and data analyses. 4. Provide information about the geological time scale.			
Credits:4			**Discipline Specific Elective**
Max. Marks: As per Univ. rules			**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**		**No. of Hours**
Unit I	Origin of Life: Concept of Oparin and Haldane and Urey; Millers Experiment. Evolution: Lamarckism, Darwinism, Evidences of Evolution Homologous and Analogous Organs. Concept of Variation, Mutation, Adaptation, Struggle for		**15**

	existence, Natural Selection, Isolation. The evolutionary synthesis.	
Unit II	Origin of Species: Categories of Species (Demes, Metapopulation, Geographical races, Ecological Races and Clines), Types of Species and Speciation. Basic pattern of Evolution (Micro, Macro and Mega Evolution).	**15**
Unit III	Pool, Gene Frequency and Hardy Weinberg's Evolution of Man. Evolutionary time scale (Geological time scale), General idea of animal paleontology. Types of fossils.	**15**
Practical		
	1. Study of evolution of horse and man (through charts/ models.) 2. Adaptive modification in feet of birds/mouthparts of Insects (through charts/ slides). 3. Embryological evidences of evolution (through chart). 4. Analogy and Homology (wings of birds and insects, forelimbs of bats and rabbits.	**30**

Recommended Readings

Textbooks:

- Evolution And Taxonomy- John Henry Comstock
- Evolution - Strickberger
- Collecting Evolution: The Galapagos Expedition that Vindicated Darwin- Matthew J. James
- Evolution: an introduction- Stephen Stearns and Rolf Hoekstra
- Evolutinary Biology- Veer Bala Rastogi

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Elementary Ichthyology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Elementary Ichthyology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY		
Programme: Bachelor Of Zoology	**Year: IV**	**Semester: VII** **Paper: DSE**
Subject: Zoology		
Course: DSE	**Course Title: Elementary Ichthyology**	

Course Outcomes:

After studying this course, the students will be able to:

- Identify the major types of fish and their characteristics.
- Understand the anatomy and physiology of fish.
- Recognize the ecological roles and environmental significance of fish.
- Classify fish into different families, orders, and classes.
- Appreciate the importance of fish conservation.

Credits:4		Discipline Specific Elective
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Introduction to Ichthyology: Definition and scope, History and importance of Icthyology Classification of fishes up to orders.	**15**
Unit II	Morphology of Fish: Body shape, Fins and types of fins, Scales and Types of scales Fish Physiology: Respiration, Digestion, Excretion, Reproduction and Sense organs system Adaptation in fish: Hill Stream and Deep Sea Adaptation.	**15**
Unit III	Construction of aquarium and its maintenance Methods of fish collection and types of nets Fish processing and preservation techniques. Pisciculture: Carp farming, Integrated fish farming, Induced breeding: Induction agents and their applications.	**15**
	Practical	
	1. To identify basis diagnostic (Morphological) features of fish 2. Age determination with the help of scale. 3. Collection of blood and smear preparation. 4. Construction and Maintenance of fish aquarium.	**30**

Recommended Readings

Textbooks

- A textbook of Fish Biology and Fisheries – S.S. Khanna and H. R. Singh

- Fish and fisheries of India – V.G. Jhingran
- The Book of Indian Fishes– Francis Day
- Freshwater Fishes of Peninsular India – K.C. Jayaram
- Freshwater Fish Diversity of India – Dahanukar, Raut, and Bhat
- Ichthyology - K.C. Pandey, Nirupama Agrawal

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Animal Ecology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Animal Ecology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VII** **Paper: DSE**
Subject: Zoology		
Course: DSE	**Course Title: Animal Ecology**	

Course Outcomes: After studying this course, the students will be able to: 1. Describe the history, introduction and nature of ecosystem. 2. Explain the biogeochemical cycles and laws. 3. Describe population and community ecology. 4. Describe wild life conservation and management. 5. Develop understanding of aquatic ecology.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Concept of Ecology, its subdivisions and scope. Biotic and Abiotic Components. Concept of habitat and niche; fundamental and realized niche. Structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).	**15**
Unit II	Laws of limiting factors and its impact on organisms. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of meta-population – demes and dispersal, interdemic extinctions, age structure pyramid. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.	**15**

Unit III	Pollution: Point and non-point sources of pollution, types of pollution, indicators of pollution. Case study of various control measures taken for pollution in India. Eutrophication: Its causes, assessment, consequences and control.	**15**
	Practical	
	1. Calculation of similarity index between different communities. 2. Calculation of concentration of dominance for different communities. 3. Calculation of Shannon Weiner Index of diversity in different communities 4. Determination of salinity and chlorinity in water samples. 5. Determination of moisture content and total organic matter in soil sample. 6. Determination of dissolved oxygen. 7. Determination of free CO2 in water sample.	**30**

Recommended Readings

Textbook:

- Ecology and Environmental Science – H. R. Singh
- Animal Population Dynamics (Outline Studies in Ecology)- R. Moss, Adam Watson
- Animal Ecology and distribution of animals {PB}- Veer Bala Rastogi
- Perspectives in Animal Ecology and Reproduction- V. K. Gupta
- Animal Ecology- S. Charles (Samuel Charles) Kendeigh
- Animal Population Ecology: An Analytical Approach (Ecology, Biodiversity and Conservation) - T. Royama
- Animal Ecology- Charles Elton
- Limnology Lake and River Ecosystem – Robert G. Wetzel

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Elementary Entomology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Elementary Entomology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY		
Programme: Bachelor of Zoology	**Year: IV**	**Semester: VII** **Paper: DSE**
Subject: Zoology		
Course: DSE	**Course Title: Elementary Entomology**	
Course Outcomes: After studying this course, the students will be able to: • Understand the Basics of Entomology • Identify and Classify Insects • Explain Insect Anatomy and Adaptations		

Credits:4		Discipline Specific Elective
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Introduction to Entomology: Definition, History and Scope. Classification of insects up to orders; Brief knowledge of general characters of following insect orders- Thysanura, Collembola, Orthoptera, Odonata, Isoptera, Herteroptera, Coleoptera, Lepidoptera, Hymenoptera and Diptera.	**15**
Unit II	Methods of insect collection and preservation. Social life in insects: honey-bee and termites. A brief account on the life-cycle, pathogenecity and control measures. Insect Life Cycles and Metamorphosis (e.g., Butterflies and Grasshoppers)	**15**
Unit III	Household insects: Cockroach and Silverfish. Insect injurious to man and Livestock: Mosquitoes, House fly and Bedbug. Economic importance of insect as food medicine. Insects in agriculture, Integrated pest management.	**15**
Practical		
	1. Collection, preservation and mounting different groups of insects fauna. 2. Identification of insects using dichotomous keys. 3. Field visit to understand forest and agricultural habitats of insects.	**30**

	4. Study of life cycles of some household and serious pest of crops and vegetables with the help of chart and models.	

Recommended Readings

Textbooks

- Insects – M.S. Mani
- Modern Entomology – D. B. Tembhare
- Elements of Entomology – Rajendra Singh and G. C. Sachan
- Entomology Refresher – K. Phani Kuamar and C. P. Viji

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Elementary Bio-technology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Elementary Bio-technology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY		
Programme: Bachelor of Zoology	**Year: IV**	**Semester: VII** **Paper: DSE**
Subject: Zoology		
Course: DSE	**Course Title: Elementary Bio-technology**	

Course Outcomes:

After studying this course, the students will be able to:

- Understand what biotechnology is and how it is used in various fields.
- Explain the basic structure of cells and DNA.
- Identify the role of microorganisms in food, medicine and the environment.
- Describe how biotechnology is used in agriculture and food production.
- Understand how vaccines, antibiotics and genetic engineering work.
- Recognize the role of biotechnology in environmental protection.
- Discuss future possibilities and ethical concerns in biotechnology.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Unit	Topic	No. of Hours
Unit I	Introduction to Biotechnology and its history. Restriction enzymes and cloning techniques used in recombinant DNA technology.	**15**

	Polymerase Chain Reaction (PCR) and its applications.	
Unit II	DNA Fingerprinting. Blotting techniques (Northern and Southern) Gene cloning techniques.	**15**
Unit III	Biotechnology in Food Production: Fermentation, Genetically modified animals. Biotechnology in Medicine: vaccines, Antibiotics.	**15**
Practical		
	1. Culture and maintenance of bacteria. 2. To extract genomic DNA from bacterial cells. 3. To carry out the spectrophotometric analysis of genomic DNA. 4. Agarose gel electrophoresis. 5. Restriction enzyme digestion of the isolated DNA.	**30**

Recommended Readings

Textbooks

- Biotechnology – David P. Clark
- Genetic Engineering – Smita Rastogi and Neelam Pathak
- Elementary Biotechnology – R.C. Dubey
- Biotechnology for Beginners – Rajiv Aggarwal
- Textbook of Biotechnology – H.K. Das

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Elementary Immunology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Elementary Immunology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY		
Programme: Bachelor Of Zoology	**Year: IV**	**Semester: VII** **Paper: DSE**
Subject: Zoology		
Course: DSE	**Course Title:** Elementary Immunology	
Course Outcomes: After studying this course, the students will be able to: • Understand the basic concepts of immunology and its importance. • Identify the major components of the immune system and their functions. • Describe how vaccines work and their role in disease prevention. • Recognize common immune-related diseases. • Discuss the role of immunology in medical advancements.		
Credits:4		**Discipline Specific Elective**

Max. Marks: As per Univ. rules		Min. Passing Marks: As per Univ. rules
Unit	**Topic**	**No. of Hours**
Unit I	Definition and principles of the immune system. Innate vs. adaptive immunity. Overview of immune cells (e.g., macrophages, T-cells and B-cells). Primary lymphoid organs (Bone marrow and Thymus). Secondary lymphoid organs (Lymph nodes and Spleen).	**15**
Unit II	Structure and function of antibodies (IgG, IgA, IgM, IgE and IgD). Antigenic determinants (epitopes). Antigen-antibody interactions. The Innate Immune Response. The Adaptive Immune Response. Immunological Disorders and Vaccination.	**15**
Unit III	Common Diseases and response of Immune System, Allergies, Autoimmune diseases and Immunodeficiency.	**15**
	Practical	
	1. Demonstration of lymphoid organs. 2. Histological study of spleen, thymus and lymph nodes through slides/ photographs 3. Preparation of stained blood film to study various types of blood cells. 4. Ouchterlony's double immuno-diffusion method. 5. ABO blood group determination. 6. Demonstration of ELISA	**30**

Recommended Readings

Textbooks

- Immunology – Kuby
- Immunology – Richard Coico and Geoffrey Sunshine
- A textbook of Immunology – P. Madhavee Latha

- Elements of Immunology – Dr. Fahim Halim Khan
- Basic Immunology – R.C. Dubey
- Textbook of Immunology – Arun Kumar and Sunil Kumar
- Immunology- Wiley Blackwell

Generic Elective (GE) – Bioinstrumentation

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Bioinstrumentation	4	4	0	0	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VII** **Paper: GE**
Subject: Zoology		
Course: GE1	**Course Title: Bioinstrumentation**	
Course Outcomes: After studying this course, the students will be able to:		

1. Understand the use of basic biomedical instrumentation, principles and techniques of Microscopy and preparative analytical centrifugation; include ultra centrifugation, sedimentation analysis and gradient centrifugation.
2. Understand the theory and application of Chromatography techniques, Gel filtration, ion exchange, affinity, HPLC and electrophoresis.

Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Principles and techniques of Microscopy; Magnification and resolution parameters of light, fluorescent phase contrast scanning, transmission electron microscopy, tunneling microscopy and Inverted microscope, Micrometry, Colony counting, Microtomy. Laboratory safety guidelines. Centrifugation – Basic principles of sedimentation, types of centrifuges, ultracentrifugation, differential and rate zonal separations, Organellar separation and Flow cytometry.	**20**
Unit II	Principle and applications of pH meter, spectroscopy UV- Vis, Mass Spectrometry (MS), X-ray Crystallography. Chromatographic techniques, Paper chromatography, partition chromatography, column chromatography, thin layer chromatography, Gas Chromatography, ion exchange, affinity chromatography.	**20**
Unit III	Introduction to HPLC, Electrophoresis: Capillary, Agarose, SDS and Native PAGE, pulse field, immuno-electrophoresis, paper electrophoresis, PCR and Thermal cyclers, Nucleic acid hybridization: Southern and Northern blotting, Western blotting, Autoradiography. ELISA, RIA.	**20**

Recommended Readings

Textbooks:

- Bioinstrumentation – M.H. Fulekar and Bhawna Pandey
- Textbook of Bioinstrumentation – Priyanka Pandey
- Bioinstrumentation – John G. Webster

Generic Elective (GE) –Histology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Histology	4	4	0	0	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY		
Programme: Bachelor Of Zoology	**Year: IV**	**Semester: VII** **Paper: GE**
Subject: Zoology		
Course: GE	**Course Title: Histology**	

Course Outcomes:

After studying this course, the students will be able to:

1. Understand the basic concepts of histo technology.
2. Interpret the characteristic structural features of tissue group and main organs.

Credits:4		Generic Elective
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Definition, scope, and significance of histology. Histological techniques: Fixation, sectioning, and staining. Basic Tissues and their types, structure and function (epithelial, connective, muscular and nervous tissue)	**20**
Unit II	Histology of Major Organ Systems: Digestive System: liver, pancreas. Respiratory System: Lungs. Excretory System: Kidney.	**20**
Unit III	Histology of Endocrine glands: Pituitary, thyroid, adrenal, Testis, Ovary.	**20**

Recommended Readings

Textbooks:

- Junqueira's Basic Histology: Text and Atlas - Anthony L. Mescher
- A textbook of Animal Histology – A.K. Berry
- Histology: A Text and Atlas - Michael H. Ross and Wojciech Pawlina
- Functional Histology - William K. Ovalle
- Textbook of Histology - Dr. P. R. Joshi
- Basic Histology - Dr. A. K. Suri and Dr. B. D. Suri

SEMESTER- VIII
BACHELOR OF ZOOLOGY WITH HONOURS

DISCIPLINE SPECIFIC COURSE (DSC) – Biology of Chordata

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITYAND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Biology of Chordata	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: DSC**
Subject: Zoology		
Course: DSC	**Course Title: Biology of Chordata**	
Course Outcomes: After studying this course, the students will be able to:		

1. Describe general taxonomic rules on animal classification of chordates.
2. Classify Protochordata to Mammalian with taxonomic keys.
3. Understand Mammals with specific structural adaptations.
4. Understand the significance of dentition and evolutionary significance.
5. Understand the origin and evolutionary relationship of different phyla from Prochordata to mammalian.

Credits:4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Classification up to orders, characters, habits and habitats of chordates. Characteristic features and affinities of the following: Protochordata, Hemichordata, Urochordata, Cephalochordata, Cyclostomes, Dipnoi. Origin of the following: Amphibian, Reptiles, Birds, Mammals, Adaptive radiation in Chordates: Aquatic, Terrestrial, Aerial, Arboreal, Fossorial	**15**
Unit II	Parental care in Amphibians, Skull in Reptiles, Venom and anti-venom in Ophidians Flightless birds, Modification of beaks (Darwin finches), feet and palate in birds, Dentition in mammals, Stomach in ruminants. General organization, classification and affinities of Cyclostomata, Gymnophiona and its affinities, Parental care in Amphibian.	**15**
Unit III	General organization, distribution and affinities of Rhynchocephalia. General organization, distribution and affinities of Crocodilian. Palate in Birds, Ratitae: Distribution and affinities, Dentition in mammals, General characters, distribution and affinities of Prototheria and Metatheria, Aquatic and flying	**15**

	adaptations in Mammals.	
Practical		
	1. Microtomy of vertebrate tissues 2. Study of the skeleton of Frog, Varanus, Chelonia, Crocodile, Snake (vertebrae and skull of poisonous and non-poisonous snake), Gallus (various types of Palates) and Rabbit 3. Study of permanent slides of Protochordates and Chordates. 4. Study of the museum specimens of Protochordata and of the different classes of vertebrates.	**30**

Recommended Readings

Textbook

- Modern textbook of zoology, Vertebrates- R. L. Kotpal
- Chordate zoology - E. L. Jordan and P. S. Verma
- CNH Series, Kotpal Series, Hyman Series
- Chordate zoology- P. S. Dhami and J. K. Dhami.
- Textbook of Chordate Zoology – G. S. Sandhu and H. Bhaskar
- Textbook of zoology, Vertebrates- A. J. Marshall.

Reference Book

- The Vertebrate Body. 6th ed. Romer AS, Parsons TS. Philadelphia: Saunders College Publishing; 1986.
- Chordate Structure and Function. 1st ed. Waterman AJ. New York: Macmillan Publishing Co.; 1971.
- Vertebrate Life. 10th ed. Pough FH, Janis CM, Heiser JB. New York: Oxford University Press; 2018.
- The Origin of Vertebrates. 1st ed. Gee H. Oxford: Oxford University Press; 1996.
- Functional Anatomy of the Vertebrates: An Evolutionary Perspective. 3rd ed. Liem KF, Bemis WE, Walker WF, Grande L. Belmont, CA: Brooks/Cole; 2001.

DISCIPLINE SPECIFIC ELECTIVE (DSE1) – Ethology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE1: Ethology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: DSE**
Subject: Zoology		
Course: DSE1	**Course Title: Ethology**	

Course Outcomes:

After studying this course, the students will be able to:

- Learn about the role of hormones, an animal's genotype and its environment in the development of behavior.
- Learn to exhibit critical and integrative thinking skills.
- Learn about the systems that affect animal behavior, such as the central neural system, hormones and

pheromones.

- Learn about physiological mechanisms that cause or modulate animal behavior, animal sensory systems and evolutionary behavioral biology.
- Learn about animal welfare issues and how animal behavior can help address these issues.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Brief history, Introduction, Significance of Study of Animal Behaviour. Behaviour Patterns: Fixed Action Pattern (FAP) or Instinctive Behaviour: Characteristics, modes Kinesis, Taxes, Reflexes, Instincts), Releasers, Innate Releasing Mechanism (IRM). Learned Behaviour or Acquired Behaviour: Non-associative learning (Habituation, Sensitization), Associative learning (Classical conditioning, Trial and Error learning), Latent learning, Insight learning (Reasoning, Intelligence, Cognitive thinking), Phase-specific learning (Imprinting, Avian Song Learning, Language learning) Memory: Nature of Memory, Positive and Negative Memory (Reasoning, Remembering, Forgetting and Retention), Types of Memory (Short-term Memory (STM), Intermediate term Memory (ITM), and Long-term Memory).	**15**
Unit II	Individual Behaviour: Conflicts (Situations, Types of conflicts, Behaviour display as an evidence of Conflict), Aggression (Forms and causes of aggression), Territoriality (Individual territories, Pair territories, Group	**15**

	territories, Use of scent, urine and faeces and special glands such as anal and salivary glands in marking territories by Mammals) Feeding Strategies: Non-selective and Selective feeding, Food begging, Courtship feeding, Predatory and Anti-predatory feeding mechanisms, Food sharing in insect societies, Parental feeding, Coprophagy Social Behaviour: Costs and benefits of group living, Types of Social Acts, Social Organizations in Termites and Primates, Parental Care in Insects, Fishes, Amphibians, Birds and Mammals.	
Unit III	Communication: Visual and Auditory communication, Infrasound communication in Elephants and Whales, Tactile communication (Dance language of honey bees), Electric communication, Chemical communication (Pheromones: Types and their functions in Insects and Mammals), Echolocation in Bats, Postures and Gestures in Mammals Migratory Behaviour: Bird Migration: Types of Migration, Causes of Migration, Advantages of Migration, Methods of Studying of Migration, Orientation and Navigation, Fish Migration: Homing, Causes of Migration, Factors influencing Migration, Fish Migration ways or Fish Ladders, Migration of Salmon, Eel and Hilsa. Biological Rhythms: Circa-annual Clocks, Circatidal Clocks, Circa-lunar or Circa-syndic Clocks, Semi-lunar Clocks, Circadian Clocks.	**15**
Practical		
	1. Study of different kinds of behaviour with the help of photographs. 2. To study different types of taxis in organisms, 3. Study of models of motivation. 4. Study of social groups and socio-biology of animals. 5. To study nesting behavior of wasps. 6. Direct and indirect sighting of birds behavior.	**30**

Recommended Readings

Textbooks

- Textbook of Animal Behaviour- Mandal Fatik Baran
- Animal Behaviour (Ethology)- V. K. Agarwal
- Animal Behaviour 6th Edition- Reena Mathur
- A Textbook of Animal Behaviour- H. S. Gundevia and Hare Govind Singh
- Animal Behavior - J. Alcock

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Research Methodology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE1: Research Methodology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII**

		Paper: DSE
Subject: Zoology		
Course: DSE1	**Course Title: Research Methodology**	

Course Outcomes:

After studying this course, the students will be able to:

- Understand the basic concepts of Research and methodology.
- Develop advance critical thinking skill.
- Define and apply appropriate parameter and research problems.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Research – types, selection and formulation of research Problem – research Design. Analytical study of Statistical Method, Historical Research. Statistics as a tool of research, Methods and demerits of statistics. Surveys, types of research methods, Case Study, Sampling types and Methods.	**15**

	Historical Method and Scientific Method. Characteristic Features of Scientific Method; Empirical Verifiable, Cumulative, Self - Correcting, Deterministic. Ethical and Ideological neutrality (Value Free), Statistical Generalizability.	
Unit II	Collection, Objectives and Classification of Data, Types of data presentation. Data Interpretation, Primary, Secondary and Tertiary Data. Data organization in SPSS and Excel, Computer and Content Analysis. Discussion and Interpretation of results. Testing of Hypothesis: Logical and Statistical Techniques.	**15**
Unit III	Locating Information on a Topic of Interest, Acquiring Copies of Articles of Interest. The Nature of Scientific Variables, Conceptual Versus Operational Definitions of Variables. Levels of Measurement, Various Paradigms. The Basic Format for a Research Report, Identification of the Parts of a Research Report. Citation and Referencing Styles. Essentials of Report Writing, Aids for Writing Good Research Report.	**15**
Practical		
	1. Usage of search engine tools for retrieving research/review papers. 2. To generate a hypothesis and design an experiment. 3. Collection of data, interpretation and writing an article (research/review papers). 4. Graphical representation and interpretation of the data provided. 5. Title and abstract writing for a given research paper.	**30**

	6. Preparation of bibliography/references in different formats as per journal requirements. 7. Usage of software tools for checking plagiarism. 8. Drug designing tools and their usage.	

Recommended Readings

Textbooks:

- Research Methodology Methods and Techniques – C R Kothari
- Research Methodology: Techniques and Applications - K. Hanumantha Rao
- Research Methodology in Social Sciences: A Practical Guide - Bagchi, Kanak Kanti
- Research Methods in Librarianship- B.A.V. Busha, C. H and Harter, S.
- Business Research Methods - Cooper, R. Donald and Pamela S. Schindler.
- Making Social Science Matter: Why Social Inquiry Fails and How it can Succeed - Flyvbjerg

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Cytology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Cytology	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: DSE**
Subject: Zoology		
Course: DSE2	**Course Title: Cytology**	
Course Outcomes: After studying this course, the students will be able to: • Understand the relationship between cell structure and function. • Correlate the relationship between cellular structure and function in the context of cell growth and death. • Understand DNA regulation and replication: Students can understand DNA regulation and replication, as well as types of DNA damage and DNA repair pathways.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Diversity of cell size, type and shape, Cell theory. Structure of Prokaryotic and Eukaryotic cells. Cellular organelles: Plasma membrane, cell wall and their structural organization; Mitochondria, Nucleus ER, Golgi complex and micro-	**15**

	bodies, Nuclear Pore complex. Organization of cytoskeleton; cell microtubules, micro filament and intermediate filaments. Molecular aspects of cell division; Cell cycle - molecular events and model system, cell cycle regulation.	
Unit II	Structure and Organisation of membranes, Glycoconjugates and Proteins in membrane system, Protein Localization, Import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis Transport of nutrients, ions and macromolecules across membranes, Passive and active transport, Na+ /K+ pump. Cellular communication: general principles of cell communication, cell adhesion molecules and roles of different adhesion molecules, gap junctions, plasmodesmata, extracellular matrix, selectins, Cadherins, integrins, neurotransmission and its regulation.	**15**
Unit III	Cellular responses to environmental signals in bacteria and animals - mechanisms of signal transduction; Endocrine, Exocrine and Synaptic signaling, Surface and intracellular receptors, G Proteins and generation of second messengers, mode of action of cAMP and Ca ++ Calmodulin, signal transduction pathways, regulation of signaling pathways. GPCR Signaling, Wnt Signaling, Notch Signaling, Hedgehog Signaling, NO Signaling, RAS-MAP Signaling. Biology of cancer: Oncogenes and Tumor Suppressor Genes, Viral and cellular oncogenes, tumor suppressor genes from humans, Structure, function and mechanism of pRB and p53 tumor suppressor proteins. Apoptosis and necrosis.	**15**
Practical		
	1. Cytology: Study of different stages of mitosis with the help of onion root tip/animal cell. 2. Study of Giant Chromosomes (Polytene and Lambrush Chromosome) 3. Preparation of DNA / RNA structure Nucleosides Nucleotides through	**30**

	chart/model. 4. Laboratory preparation of following models using beads and wire. • Adenosine triphosphate (ATP). • DNA and RNA bases Nucleosides Nucleotides.	

Recommended Readings

Textbooks:

- Cell and Molecular Biology – DeRobertis and DeRobertis
- Molecular Biology of the Cell – Alberts
- Cell Biology – P.S. Verma
- The Cell: A Molecular Approach- Geoffrey M. Cooper and Robert E. Hausman
- A Text Book Of Cell Biology And Genetics- Veer Bala Rastogi
- Cell Biology Genetics Molecular Biology- Halder Kar
- Cell Biology and Genetic- V. R. Dnyansaga

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Biotechniques

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Biotechniques	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: DSE**
Subject: Zoology		
Course: DSE2	**Course Title: Biotechniques**	
Course Outcomes: After studying this course, the students will be able to: • Understand the use of basic biomedical instrumentation, principles and techniques of preparative analytical centrifugation; include ultra-centrifugation, sedimentation analysis and gradient centrifugation. • Understand the theory and application of Chromatography techniques, Gel filtration, ion exchange, affinity, HPLC and electrophoresis.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**

Theory

Unit	Topic	No. of Hours
Unit I	Principles and Techniques of Microscopy; Magnification and Resolution Parameters of Light, Fluorescent Phase Contrast Scanning, Transmission Electron Microscopy, Tunneling Microscopy and Inverted Microscope,	**15**

	Micrometry, Colony Counting and Microtomy. Laboratory Safety Guidelines. Centrifugation – Basic Principles of Sedimentation, Types of Centrifuges, Ultracentrifugation, Differential and Rate Zonal Separations, Organellar Separation and Flow Cytometry.	
Unit II	Principle and Applications of Ph Meter, Spectroscopy UV- Vis, Mass Spectrometry (MS) and X-Ray Crystallography. Chromatographic Techniques, Paper Chromatography, Partition Chromatography, Column Chromatography, Thin Layer Chromatography, Gas Chromatography, Ion Exchange, Affinity Chromatography and Introduction to HPLC.	**15**
Unit III	Electrophoresis: Capillary, Agarose, SDS and Native PAGE, Pulse Field, Immuno- Electrophoresis and Paper Electrophoresis. PCR and Therma lCyclers, Nucleic Acid Hybridization: Southern and Northern Blotting, Western Blotting, Autoradiography. ELISA and RIA.	**15**
Practical		
	1. Media preparation and sterilization for animal cell culture 2. Primary cell culture of fish organ 3. Restriction digestion of plasmid DNA/genomic DNA 4. PCR for cloning a DNA segment 5. Construction of circular and linear restriction map from the data provided 6. To study - Southern Blotting, Northern Blotting and Western Blotting 7. To study - DNA Sequencing, Sanger's Method, DNA fingerprinting 8. Good Laboratory Practices (GLP); ELISA (Demo online).	**30**

Recommended Readings

Textbooks

- Basic Biotechniques – P. Cheena Chawla

- Biotechniques – M.V. Radakrishnan
- Basic Biotechniques – P. Ruban
- Biotechniques – P. Ponmurugan
- Bioinstrumentation (ynthesis Lectures on Biomedical Engineering)- John Enderle
- Bioinstrumentation- L. Veerakumari

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Advance Genetics

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Advance Genetics	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: DSE**
Subject: Zoology		
Course: DSE3	**Course Title: Advance Genetics**	

Course Outcomes:

After studying this course, the students will be able to:

- Understand Mendelian genetics principles to understand gene interactions, multiple alleles, and sex-linked inheritance.
- Understand principles of chromosome structure and gene frequencies to understand inherited disorders and population genetics.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Chromosomal analysis, Banding techniques, Sex-chromatin techniques, Autoradiography, Chromosomes: Structure, chemical composition, classification, folded fibre model and nucleosome model, karyotype, euchromatin and heterochromatin, Giant chromosomes, B-chromosomes. Concept of gene: Allele, multiple alleles, isoallele, pseudoallele. Chromosome mapping: Chromosome mapping in Drosophila (single and double crossing over), human chromosomes (Somatic cell genetics) Mutation: Type and mechanism and effects.	**15**
Unit II	Mendelian genetics: Dominance, segregation, independent assortment, Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, linkage and crossing over. Gene mapping, Point crosses, Qualitative trait loci (QTL), Extra chromosomal	**15**

	inheritance: Inheritance of mitochondrial and chloroplast genes.	
Unit III	Microbial genetics: Methods of genetic transfers – conjugation, transformation, transduction (generalized and specialized transduction) and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. Plasmids, IS Elements, Transposons and Retro-Elements: Plasmids, inversion sequences of IS-elements, Transposons and controlling elements in prokaryotes and eukaryotes.	**15**
	Practical	
	1. Study of various Drosophila mutants 2. Mendelian and Non- mendelian based Experiments 3. Karyotyping technique for chromosomal analysis. 4. Study of Giant chromosomes (Lampbrush and Polytene Chromosome)	**30**

Recommended Readings

Textbooks

- Cell Biology, Genetics, Evolution and Ecology (multicolor edition): Evolution And Ecology- P. S. Verma and V. K. Agarwal
- Principles of Genetics – E. J. Gardner
- Concepts of Genetics – Williams
- Introduction to Genetic Analysis – Anthony J. F. Griffiths
- A Text Book of Cell Biology And Genetics- Veer Bala Rastogi
- Cell Biology Genetics Molecular Biology- Halder Kar
- Cell Biology and Genetic-V. R. Dnyansaga

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Biomedical Technologies

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Biomedical Technologies	4	3	0	1	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: DSE**
Subject: Zoology		
Course: DSE3	**Course Title: Biomedical Technologies**	

Course Outcomes:

After studying this course, the students will be able to:

- After studying this course, the students will be able to the fundamental concepts of biomedical instrumentation, focusing on the principles, operation, and application of medical devices, sensors used in healthcare, medical imaging techniques used in the diagnosis and treatment of diseases and medical implants, prosthetics, and tissue engineering.

- Understand the fundamental concepts, basic principles and function of Biological systems.
- Learn techniques relevant for medical diagnostics.
- Learn about the emphasis of new technologies for medical advancement.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Biomedical Instrumentation and Sensors: Introduction to medical instrumentation and biomedical signal processing; Sensors and transducers for biomedical applications; Biopotential measurements (ECG, EEG, EMG); Patient monitoring systems; Bioelectric signals and noise reduction techniques.	**15**
Unit II	Medical Imaging Techniques: X-ray, CT, and MRI imaging principles; Ultrasound and Doppler imaging; Positron Emission Tomography (PET) and Single Photon Emission CT (SPECT); Medical image processing and analysis; 3D imaging and virtual surgery technologies	**15**
Unit III	Biomaterials and Tissue Engineering: Types of biomaterials: metals, polymers, ceramics, and composites; Biocompatibility, biodegradability, and material testing; Tissue engineering principles and scaffold design; Stem cell technology and its application in regenerative medicine; Drug delivery systems and nanomaterials in medicine.	**15**

	Practical	
	1. Practical training in a range of techniques that are fundamental in biomedical research including assessment organ-bath assessment of ligand-receptor interactions, radioligand binding assays, diagnostic applications of enzyme kinetics, history and design of structure of clinical trials, systematic review approaches and meta-analysis. 2. Understanding of receptor pharmacokinetics, pre-clinical methods used in drug screening and development, enzyme-linked diagnostics, clinical trial structure and the systematic, statistical evaluation of clinical trial data.	**30**

Recommended Readings

Textbooks

- Biomedical Technology And Devices, 2nd Edition, Moore, James E and Duncan J Maitland
- Handbook of Biomedical Instrumentation [May 01, 2003] by R.S. Khandpur.
- Introduction to Biomedical Equipment Technology (4th Edition) by Joseph J. Carr
- Biomedical Instrumentation and Measurements - Leslie Cromwell, Fred J. Weibell, and Erich A. Pfeiffer (Pearson Education)
- Introduction to Medical Imaging: Physics and Technology - Nadine Barrie Smith and Andrew Webb (Cambridge University Press)
- "Biomaterials Science: An Introduction to Materials in Medicine" - Buddy D. Ratner, Allan S. Hoffman, and Robert L. Schoen (Academic Press)
- "Principles of Tissue Engineering" - Robert Lanza, Robert Langer, and Joseph P. Vacanti (Elsevier Science)

Generic Elective (GE) – General Biotechnology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: General Biotechnology	4	4	0	0	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: GE**
Subject: Zoology		
Course: GE1	**Course Title: Biotechnology**	

Course Outcomes:

After studying this course, the students will be able to:

1. To understand principles of animal culture, media preparation.
2. To explain *in-vitro* fertilization and embryo transfer technology.
3. To get insight in applications or recombinant DNA technology in agriculture, production of therapeutic

proteins.

4. To describe commercial production of fuels, microbial enzymes.

Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Origin and definition of biotechnology, Scope and importance of biotechnology, Biotechnology in India. Basic introduction: Recombinant DNA Technology (Tools and techniques), Restriction and modification enzymes; Vectors: Plasmid, Bacteriophage and other viral vectors, Cosmids, Ti-plasmid, Yeast Artificial Chromosome; Polymerase chain reactions; DNA fingerprinting; Southern, Western and Northern blotting; In-situ hybridization and Molecular markers. Gene therapy and Gene Delivery methods – Background, Types of gene therapy (*ex-vivo* and *in-vivo*), choosing targets for gene therapy, Vectors in gene therapy, Retroviruses, Adenoviruses, Adeno-associated viruses. Viral delivery (Retroviral vectors and Adenoviral vectors), non-viral delivery. Vaccines – nucleic acid vaccines, Biopharming and edible vaccines, immuno-enhancing technology.	**20**
Unit II	Transplantation biology – Terminology, Technology behind it, Organ donors, Social and ethical issues. Xenotransplantation and tissue engineering. Stem cell cultures, Human embryonic stem cell culture, cryopreservation of Umbilical cord stem cells and their potential use. Genetic engineering in animals: Transgenic animals and their applications. Transgenic gens and various transgenic animal models. Therapeutic products produced by genetic engineering-blood proteins, Human hormones, Immune modulators and	**20**

	vaccines, Embryo transfer technology and artificial insemination. Social issues of transgenics and IPR- public opinions against the molecular technologies. Legal issues – legal actions taken by countries for use of the molecular technologies.	
Unit III	Ethical issues – Ethical issues against molecular technologies. Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National and International. Intellectual Property Rights – Why IPR is necessary, TRIPS and IPR, IPR – National and International scenario, IPR protection of life forms. Bioremediation – Petroleum prospecting and formation of oil spills, Wastewater treatment, Chemical degradation, heavy Metals. Introduction to Bioreactor: Types and operation of Bioreactors, Physico-chemical standards used in bioreactors, Limitations of bioreactors.	**20**

Recommended Readings

Textbooks

- Practical Techniques in Molecular Biotechnology- Bal Ram Singh and Raj Kumar
- Biotechnology: A Problem Approach- Pranav Kumar and Usha Mina
- Textbook of Biotechnology- H. K. Das
- A Textbook of Biotechnology-R. C. Dubey
- Molecular Biotechnology - Bernard
- Biotechnology - A Textbook Of Industrial Microbiology- W. Crueger

Generic Elective (GE) – Parasitology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Parasitology	4	4	0	0	Passed Class XII with Biology	Nil

BACHELOR OF ZOOLOGY WITH HONOURS		
Programme: Bachelor of Zoology With Honours	**Year: IV**	**Semester: VIII** **Paper: GE**
Subject: Zoology		
Course: GE2	**Course Title: Parasitology**	
Course Outcomes: After studying this course, the students will be able to: • Understand the interaction of various host parasites. • Understand the parasitic adaptation in various ecto and endo Parasites. • Understand the various vectors of disease causing parasite.		
Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**

Unit I	Parasitism and evolution of parasitism. Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of Man their Preventive and control measures (*Entamoeba histolytica*, *Trypanosoma, Leshmania donovani, Trichomonas vaginalis, Giardia intestinalis* and *Plasmodium*)	**20**
Unit II	Parasitic adaptations in Platyhelminthes and Aschelminthes. Common trematode, cestodea and nematode parasites. Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris, Schistosoma, Faciola, Wuchereria, Taenia).*	**20**
Unit III	Introduction to arthropods and vectors of human diseases (mosquitoes, lice, flies and ticks). Parasites in Crutaceans.	**20**

Recommended Readings

Textbooks

- Textbook of Microbiology with Parasitology, 7/e – 2024- D. R. Arora and Brij Bala Arora
- Textbook of Medical Parasitology : Protozoology and Helminthology, 4th Edition- Subhash Chandra Parija
- Parasitology Protozoology And Helminthology 13Ed (Hb 2019): (Protozoology and Helminthology)- K. D. Chatterjee
- Textbook of Medical Parasitology- Sumeeta Khurana and Abhishek Mewar
- Textbook of Human Parasitology, Protozoology and Helminthology (PB 2020)- R. Sood

SEMESTER- IX
MASTER'S IN ZOOLOGY

DISCIPLINE SPECIFIC COURSE (DSC) – General Ichthyology/ Systematic and Applied Entomology/General Animal Biotechnology / Fundamentals of Immunology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSC: Ichthyology-I A (General Ichthyology)	4	3	0	1	Passed Class XII with Biology	Nil
Entomology-I A (Systematic and Applied Entomology)						
Animal Biotechnology –I A (General Animal Biotechnology)						

Immunology – I A (Fundamentals of Immunology)						

MASTER'S IN ZOOLOGY		
Programme: Master's in Zoology	**Year: V**	**Semester: IX** **Paper: DSC**
Subject: Zoology		
Course: DSC	**Course Title: Ichthyology-I A (General Ichthyology)**	
Course Outcomes: After studying this course, the students will be able to: 1. Understand the general form, function, and diversity of fish. 2. Understand the morphological and physiological adaptations of fish and their role in the aquatic environment. 3. Understand general concepts of biogeography and evolution of fish. 4. Applying principles of phylogeny to understand fish adaptations. 5. Becoming familiar with principles of ecology and behavior of fish. 6. Learning basic external and internal anatomy of fish.		
Credits:4		**Discipline Specific Course**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**

Unit I	Classification of fishes, Systematic position, habit and habitat, morphology, distribution, significance and affinities of Holocephali and Dipnoi. Fins, their origin and evolution; Locomotion in fishes. Histomorphology and elementary physiology (a) digestive system (with particular reference to food and feeding habits of freshwater fishes) (b) excretory system (with particular reference to acid base balance and osmoregulation).	**15**
Unit II	General survey of the marine, estuarine and inland capture fisheries of India with particular reference to fishery resources of Uttaranchal. Methods of fishing: Fishing gears and crafts. Cold water fishery Sewage-fed fishery, Shell–fish fishery. Nutrition and growth including age and growth relationship, chemical composition of fish flesh, length –weight relationship, Natural food and artificial feed and their role in fish culture. Plankton and benthos in relation to fish production.	**15**
Unit III	Electric organs in fishes. Accessory respiratory organs in fishes. Brief knowledge of sexual dimorphism, courtship and parental care. Migratory instincts, Hill stream adaptations Reproduction in a major carp- structure of gonad, spawning, early development and metamorphosis. Microscopic structure and hormonal functions of the following endocrine glands: Pituitary, Thyroid, Pancreas, Adrenal, Corpuscles of Stannins, Ultimobranchial glands, caudal neurosecretory system and Sex hormones. Current trends in induced breeding in fishes. Brief knowledge of sense organs: organs of smell, eyes, hearing, ampulla of Lorenzeni, Bioluminescence, sound production and lateral line system.	**15**
Practical		
	1. Fish collection, tools and types of net used in fish sampling. 2. Fish Identification, Classification and Taxonomic studies of fresh water fishes.	**15**

	3. Study of preserved fish specimens. 4. Detailed study of the skeleton of a Cyprinoid and a Siluroid fish. 5. Permanent preparation of scales, sensory, Ampullae etc. 6. Aquarium fabrication, setting and its Maintenance. 7. Different types of modern fish farming techniques used in Uttarakhand. 8. Determination of age with the help of scales. 9. Calculation of Gonado- Somatic Index and Determination of fish fecundity. 10. Analysis of basic hematological parameters of fish blood and preparation of permanent slide of fish blood. 11. Project Work and Field Report, field visits will be integral part of the Practical.	

Recommended Readings

Textbooks

- Textbook of Ichthyology- K. C. and Nirupama Agrawal Pandey
- A textbook of Fish biology and Fisheries – S. S. Khanna and H. R. Singh
- Fish Physiology- William Stewart Hoar and David J. Randall
- Fishes: A Guide to Their Diversity- Philip A. Hastings, H. G. Greene, and Conrad Limbaugh
- An Introduction to the Study of Fishes by James S. Nelson, Terry C. Grande, and Mark V. H. Wilson

Reference Book

- The Physiology of Fishes. 4th ed. Evans DH, Claiborne JB, Currie S. Boca Raton, FL: CRC Press; 2013.
- Fish Ecology. 1st ed. Pitcher TJ. New York.
- Ecology of Fishes. 1st ed. Wootton RJ. Dordrecht.
- Fish and Fisheries of India. 3rd ed. Jhingran VG. Delhi: Hindustan Publishing Corporation.
- Freshwater Fishes of the World. 1st ed. Axelrod HR, Burgess WE, Pronek N. New Jersey: TFH

Publications.

OR

Course: DSC	**Course Title: Entomology-I A (Systematic and Applied Entomology)**

Course Outcomes:

After studying this course, the students will be able to:

1. Student will be able to classify insect up to their respective orders.
2. Understand the difference in the life cycles of insects.
3. Student will be able to describe various ecological importance of insects.
4. Understanding insect biology: Including general entomology, basic systematics, morphology, physiology and biodiversity.

Credits:4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Ancestry and evolution of insects, Classification of insects, Principles of construction and use of dichotomous keys in insect. Methods of collection, preservation, Mounting and culture of insects. Brief knowledge of habit, habitats and general characters of the following orders with special reference to the families mentioned: Thysanura, Collembola, Odonata, Orthoptera (Acrididae, Tettigoniidae, Gryllidae), Phase theory in locusts, Phthiraptera (Anoplura,	**15**

	Mallophaga), Isoptera, Thysanoptera, Heteroptera (Pentatomidae, Belostomatidae), Homoptera (Aphidae, Coccidae), Coleoptera (Coccinellidae, Curculionidae, Scarabaeidae), Lepidoptera (Pireidae, Nymphalidae, Papillionidae, Noctuidae, Sphingidae), Hymenoptera (Apidae, Ichneumonidae, Formicidae); Diptera (Muscidae, Culicidae, Syrphidae).	
Unit II	Principles and Practices of Pest Control: Pests defined: Categories of crop pests (key pests, occasional pests, potential pests and migratory pests) Pest control procedures: Natural control, Applied control (Cultural, Biological and Insecticidal) Modes of action of insecticides, factors affecting toxicity of insecticides Non-insecticidal methods: Anti-feedents, Attractants and Repellents, Feeding deterrents, Chemosterilants, Pheromones and Insect Growth Regulators (IGR's).	**15**
Unit III	Integrated Pest Management (IPM) Insecticide Application Equipments: Sprayers, Dusters, Granule Applicators Distribution, habit and habitats, life-cycle, nature of damage and control of pests of: Stored grains (*Sitophilus oryzae, Triboliumcastaneum, Callosobruchus chinensis*); Sugarcane (*Pyrillaperpusilla, Chio infuscatellus*); Paddy (*Leptocorisa acuta, Hieroglyphus banian/nigrorepletus*), Cotton (*Dysdercuskoengii, Pectinophoragossypiella*); Cereals (*Heliocoverpaarmigera, Agrotisipsilon*) Vegetables (*Raphidopalpa (=Aulacophora) foveicollis, Pieris brassicae*); Fruits (*Bactrocera (=Dacus) cucurbitae, Papilio demoleus*); Forests (Defoliator: Tasar silkworm, *Antheraea paphia*; Sapsucker of Khamer or Gamhar, *Tingisbeesoni*; Teak borer, *Aeolesthesholosericea*); and Polypha Pests (Locusts, Termites)	**15**
Practical		
	1. Hands on training of Equipments and accessories used in collection of insects.	**15**

	2. Hands on training of Equipments and accessories used in mounting and preservation of insects. 3. Survey of representative insect order in the forest, orchards, crop lands etc. 4. Prepare a chart or model of classification of insects up to family level. 5. Identification of insects using dichotomous keys up to family level. 6. Life-cycle of different kinds of insect pests i.e. cereals (Sugarcane, Wheat, Rice), vegetables, fruits, cotton and stored grains. 7. Life-cycle of defoliator insects. 8. Taxonomic status, Life-cycle of Honey bee. 9. Taxonomic status, Life-cycle of Silk moth. 10. Taxonomic status, Life-cycle of Lac insect. 11. Life-cycle of House fly and Mosquito. 12. Comment on general characteristics, classification and habit, habitat of preserved museum insects. 13. Calculation of secondary productivity of herbivorous insects. 14. Sampling techniques for estimation of insect population. 15. Ecological adaptation of aquatic insects. 16. Project Work and Field Report, field visits will be integral part of the Practical.	

Recommended Readings

Recommended text

- A textbook of Entomology – Dr. Mathur and Dr. Upadhyay
- Modern Entomology – D. B. Tembhare
- Agricultural Pests of South Asia and their management – A. S. Atwal and G. S. Dhaliwal
- The Insects Structure and Function – R.F. Chapman

- Principles of Insect Morphology- R. E. Snodgrass
- Introduction to Insect Pest Mangaement – Robert L. Metcalf and William H. Luckmann
- Introduction to General and Applied Entomology- V. B. Awasthi
- Entomology: An Introduction- George C. McGavin
- The Insects: An Outline of Entomology- P. J. Gullan and P.S. Cranston
- Insect Ecology: Behavior, Populations, and Communities- Peter W. Price

Reference Book

- Agricultural Entomology. 1st ed. Pedigo LP, Rice ME. Boston: Academic Press; 2009.
- Insect Pest Management. 2nd ed. Dent D. Wallingford: CABI Publishing; 2000.
- Systematic Entomology. 1st ed. Gullan PJ, Cranston PS. Chichester: Wiley-Blackwell; 2014.
- Medical and Veterinary Entomology. 2nd ed. Mullen GR, Durden LA. Amsterdam: Academic Press; 2009.
- Applied Entomology: An Introductory Textbook. 1st ed. Dhaliwal GS, Arora R. New Delhi: Kalyani Publishers; 2004.

OR

Course: DSC	**Course Title: Animal Biotechnology –I A (General Animal Biotechnology)**

Course Outcomes:

After studying this course, the students will be able to:

1. Successfully maintain cultures of animal cells and established cell lines with good viability, minimal contamination and appropriate documentation.
2. Perform supportive or episodic tasks relevant to cell culture, including preparation and evaluation of media, cryopreservation and recovery, and assessment of cell growth/health.
3. Recognize and troubleshoot problems common to routine cell culture.

Credits:4		Discipline Specific Course
Max. Marks: As per Univ. rules		Min. Passing Marks: As per Univ. rules
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Animal Cell Culture: Equipment and materials for animal cell culture technology. Design and layout of culture room, Sterilization and aseptic techniques. Culture medium: natural media, synthetic media, sera. Introduction to balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, role of carbon dioxide, serum and supplements in animal cell culture. Characteristics of cells in culture: Contact inhibition, anchorage dependence, cell-cell communication. Mechanical and enzymatic disaggregation of tissue and setting up of primary cultures, Candling of eggs, preparation of chick fibroblast, culture of lymphocytes for chromosomal studies. Roller and Suspension culture techniques.	**15**
Unit II	Large-scale production of cells using bioreactors, micro- carries and perfusion techniques. Measurement of viability and cytotoxicity. Biological characterization of the cultured cells, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures. Fermentation technology for the growth of animal cells and their products (Bioreactors, Hollow fiber reactors, Air-lift fermentors, chemostats and microarriers). Established cell line cultures: Definition of cell lines, maintenance and management; cell adaptation. Stem cell cultures, embryonic stem cells and their applications. Somatic cell genetics. Organ and histotypic cultures. Cell cloning, cell	**15**

	synchronization and cell manipulation.	
Unit III	Various methods of separation of cell types, advantages and limitations; flow cytometry. Production and characterization of monoclonal antibodies and their application. Commercial applications of animal cell culture: cell culture-based vaccines, Tissue culture as a screening system; cytotoxicity, in vitro testing of drugs and diagnostic tests. Mass production of biologically important compounds (e.g. Vaccines and Pharmaceutical proteins). Production of recombinant hemoglobin, blood substituents, artificial blood. Harvesting of products, purification, and assays. Three dimensional cultures and tissue engineering (artificial skin and artificial cartilage).	**15**
Practical		
	1. Media preparation and sterilization for animal cell culture 2. Primary cell culture of fish organ 3. Restriction digestion of plasmid DNA/genomic DNA 4. PCR for cloning a DNA segment 5. Construction of circular and linear restriction map from the data provided 6. To study - Southern Blotting, Northern Blotting and Western Blotting 7. To study - DNA Sequencing, Sanger's Method, DNA fingerprinting 8. Good Laboratory Practices (GLP); ELISA (Demo online). 9. Project Work and Field Report, field visits will be integral part of the Practical.	**15**

Recommended Readings

Textbook

- Animal Cell Culture and Technology- Veer Bala Rastogi and Nirvika Rastogi

- Animal Cell Culture and Technology (The Basics (Garland Science)- Michael Butler
- Animal Cell Culture and Technology. 2nd ed. Butler M. Boca Raton, FL: CRC Press; 2003.
- Basic Cell Culture Protocols. 4th ed. Helgason CD, Miller CL. New York: Humana Press; 2012.
- Animal Cell Culture: Concepts and Applications. 1st ed. Shivaji S, Prasad AK, Kumar S. Hyderabad: Universities Press; 2010.

Reference book

- Cell Culture Bioprocess Engineering. 1st ed. Xing J, Kenty BM, Li ZJ, Lee SS. Cham: Springer; 2020.
- Mammalian Cell Biotechnology in Protein Production. 1st ed. Spier RE. Cambridge: Cambridge University Press; 2008.
- Principles and Practice of Animal Tissue Culture. 1st ed. Bhattacharya S. Hyderabad: Universities Press; 2012.
- Stem Cells and Cloning. 2nd ed. Lanza RP, Gearhart J, Hogan B, Melton D, Pedersen R, Thomas ED, et al. Amsterdam: Academic Press; 2009.
- Biotechnology of Animal Cells in Vitro. 1st ed. Davis JM. Weinheim: Wiley-VCH; 2011.

OR

Course: DSC	**Course Title: Immunology – I A (Fundamentals of Immunology)**

Course Outcomes:

After studying this course, the students will be able to:

1. Understand Immunology and the way it is applied in diagnostic and therapeutic techniques and research.
2. Train the students with essentiality of molecules, cells, tissues and organs involved in the defense mechanism.
3. Learn of techniques involved in understanding the immunological aspects of physiology and biological samples.

Credits:4		**Discipline Specific Course**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Introduction and Historical Background: Cells and Organs of Immune system Definition, Overview of immune system- Anatomical, Physiological and Inflammatory barriers. Major contribution of following scientists- Edward Jenner, Jacob Henle, Louis Pasteur, Joseph Lister, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Emil von Behring, Jules Bordet, Karl Landsteiner, Jules Freund, Peter Gorer and George Snell, Tiselius and Kabat, Gerald Eldelman and Rodeny Porter, Cesar Milstein and Georges Kohler, Peter Doherty and Rolf Zinkernagel Hematopoiesis – formation of B-lymphocytes and T-lymphocytes and its regulation. Cells of the immune system- NK Cells, B-lymphocytes, T-lymphocytes, Granulocytic cells, Dendritic cells Primary lymphoid organs and their functional role- Bone marrow, Thymus. Secondary lymphoid organs and its functional role- Lymph nodes, Spleen, Mucosal-Associated Lymphoid Tissue [MALT], Intraepithelial Lymphocytes [IEL], Cutaneous-Associated Lymphoid Tissue [CALT]	**15**
Unit II	Antigen and Immunogen, Structure and Function of Immunoglobulins, Structure and function of MHC: Antigen- definition and its properties. Immunogen-definition and its properties. Antigenecity vs. Immunogenicity and factors affecting it. Haptens and	**15**

	Adjuvants. Basic structure of immunoglobulin. Classes of immuglobulin and its biological activities. Major Histocompatibility Complex [MHC] - Structure, types and function. Regulation of MHC expression. Production of Monoclonal antibodies, its mechanism [de novo and salvage pathway] and application in research and health.	
Unit III	Primary and Secondary line of Defence [Innate and acquired immunity], Antigen-Antibody interactions: Innate immunity- Phagocytic barriers. Antigen presenting cells. Antigen processing and presentation. Acquired immunity- B-cell mediated immunity, T-cell mediated immunity its mechanism and regulation. Immune memory of B-lymphocytes. Structure of antibody, Treatment of antibody with pepsin, papain, β-mercaptoethanol and DMSO. Interaction of Antigen-Antibody- antibody affinity, antibody avidity, cross reactivity, precipitation reactions, Agglutination reactions	**15**
Practical		
	1. ELISA (Enzyme-Linked Immunosorbent Assay) for detecting the presence of specific antibodies or antigens in a sample. 2. Flow Cytometry to analyze the expression of specific cell surface markers on immune cells. 3. Western blotting to analyze the expression of a particular protein in immune cells or tissues. 4. Immuno fluorescence microscopy to visualize the distribution of antigens or antibodies in immune cells or tissues. 5. Mixed Lymphocyte Reaction to measure the proliferation of T cells in response to stimulation by alloantigens from another individual. 6. Project Work and Field Report, field visits will be integral part of the Practical.	**15**
Recommended Readings **Textbooks**		

- Textbook of Fundamental Immunology- Dr. Varun Kumar Sharma
- Kuby Immunology- Judy Owen, Jenni Punt, Sharon Stranford, and Patricia Jones
- Basic Immunology: Functions and Disorders of the Immune System- Abul Abbas, Andrew H. Lichtman, and Shiv Pillai
- The Immune System- Peter Parham

Reference Book

- Cellular and Molecular Immunology. 10th ed. Abbas AK, Lichtman AH, Pillai S. Philadelphia: Elsevier; 2022.
- Essential Immunology for Surgeons. 1st ed. Wood PJ, Slapak M, Tamimi RM. Cambridge: Cambridge University Press; 2004.
- Clinical Immunology: Principles and Practice. 5th ed. Rich RR, Fleisher TA, Shearer WT, Schroeder HW Jr, Frew AJ, Weyand CM. Philadelphia: Elsevier; 2018.
- The Immune System. 5th ed. Parham P. New York: Garland Science; 2021.
- Introduction to Immunology. 1st ed. Goldsby RA, Kindt TJ, Osborne BA. New York: W.H. Freeman; 2006.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Mammalian Endocrinology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Mammalian Endocrinology	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's in Zoology	**Year: V**	**Semester: IX** **Paper: DSE**
Subject: Zoology		
Course: DSE1	**Course Title: Mammalian Endocrinology**	

Course Outcomes:

After studying this course, the students will be able to:

- Understand the role of hormones in regulating various physiological processes in mammals, including metabolism, growth, reproduction and stress response.
- Learn about the anatomy and function of major endocrine glands such as the pituitary, thyroid, adrenal, pancreas and gonads, as well as the hormones they produce and their mechanisms of action.
- To analyze and interpret feedback mechanisms involved in endocrine regulation, including negative and positive feedback loops, and understand how disruptions in these mechanisms can lead to endocrine disorders.
- Apply their knowledge of mammalian endocrinology to real-world scenarios, such as diagnosing and treating endocrine disorders, understanding the hormonal basis of diseases, and designing hormone-based therapies.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per**

		Univ. rules
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Brief history and scope of endocrinology. Chemical nature, classification and mode of secretion of hormones, hormonal feedback in homeostasis. Mechanisms of hormone action: Complete knowledge of the generalized mechanisms of action (at molecular level) of protein (Plasma membrane mediated actions as well as intracellular CAMP mediated actions) and steroid hormones (nuclear activity mediated actions).	**15**
Unit II	Hypothalamo- hypophysial System: General organization, Neuro-hypohysial octapeptides, Adeno-hypophysial hormones. Detailed structure of mammalian Pituitary gland and synthesis, storage, control of release, transport, denaturation, physiological actions, morphological and chemical consequences of excess and deficiency of various pituitary hormones. Endocrine Pancreas: Detailed structure, Biosynthesis and physiological actions of insulin and glucagon. Thyroid Gland: Detailed structure, biosynthesis of thyroid hormones, control of secretion, transport, denaturation, physiological roles, morphological and chemical consequences of excess and deficiency of various thyroid hormones.	**15**
Unit III	Parathyroid Gland: Synthesis of parathyroid hormones, Role of parathormone: Calcitonin and vitamin-D in calcium homeostasis. Adrenal gland: Adrenal Cortex: Detailed structure, Organization, physiological roles and control of mineralocorticoides and glucocorticoids secretion. Adrenal Medulla: Detailed structure, Catecholamine, biosynthesis, release and its physiological roles. Pineal	**15**

	gland: Detailed structure, physiological actions of pineal hormones. Reproductive endocrinology: Molecular structure, origin, release and transport of sex hormones and their role in reproductive physiology (Hormonal regulation of Oestrus and Menstrual cycle and that of lactation). Environmental endocrinology: A brief knowledge of environmental endocrinology.	
Practical		
	1. Study of the Mammalian Pituitary, Thyroid Gland, Parathyroid Gland, Adrenal gland, Pineal Glands, Pancreas etc. 2. Disorders related to Endocrine Glands with the help of chart / photographs/ models. 3. To perform the technique of home test kit for pregnancy.	**30**

Recommended Readings

Textbooks

- Endocrinology – Mac E. Hadley
- Mammalian Endocrinology – B. N. Yadav
- Concepts of Endocrinology – F.Y. Peyami
- Mammalian Endocrinology and Male Reproductive Biology- Shio Kumar Sing
- Mammalian Endocrinology- Ashoke Kumar Boral
- Mammalian Endocrinology- Manju Yadav
- Mammalian Physiology: A Course of Practical Exercises- Charles Scott Sherrington
- Mammalian Endocrinology- Raghvendra Puri

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Reproductive Health

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Reproductive Health	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's in Zoology	**Year: V**	**Semester: IX** **Paper: DSE**
Subject: Zoology		
Course: DSE1	**Course Title: Reproductive Health**	

Course Outcomes:

After studying this course, the students will be able to:

- Understand the Concept of Reproductive Health
- Explain Human Reproductive Systems
- Describe Reproductive Health Issues and Solutions
- Understand Family Planning and Contraception

Credits:4		Discipline Specific Elective
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Reproductive Health- historical aspects and significance. Right to healthy and respectful relationships, health services. Safe and appropriate access to accurate information. Effective and affordable methods of contraception Access to timely support and services. Sexually transmitted diseases (HIV, reproductive tract) and their containment.	**15**
Unit II	Sex education, contraception and health care in pregnancy. Historical trends in maternal and neonatal outcomes. The ante- natal, perinatal, postpartum and new born care. Providing high-quality services for family planning, including infertility services. Abortions and their health implications	**15**
Unit III	Birth control, meaning and role in population regulation. Significant facts about birth control. Genetic Abnormalities. Human Immunodeficiency Syndrome (HIV/AIDS) and human reproductive health.	**15**

	Pregnancy and Diet. Family Size, sexual healthy life and significance. Care and its importance for mother and the growing baby. Public Aspects of Human Sexuality and Family Planning. Legal measures and the reproductive health.	
	Practical	
	1. Study of animal house: set up and maintenance of animal house 2. breeding techniques, care of normal and experimental animals 3. Examination of vaginal smear rats from live animals 4. Surgical techniques: principles of surgery in endocrinology 5. Ovarectomy, hysterectorny, castration and vasectomy in rats 6. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems 7. Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina 8. Human vaginal exfoliate cytology 9. Sperm count and sperm motility in rat; Study of modern contraceptive devices.	**30**

Recommended Readings

Textbooks:

- Human Reproductive Biology, 2006 by Kristin H. Lopez and Richard E Jones, Academic Press.

- Essentials of Gynecology by Snehamay Chaudhary.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Developmental Biology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Developmental Biology	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: IX** **Paper: DSE**
Subject: Zoology		
Course: DSE2	**Course Title: Developmental Biology**	
Course Outcomes: After studying this course, the students will be able to: 1. Understand the basic concepts of developmental biology.		

2. Understand the concept of hormonal regulation of reproduction. 3. Describe the morphological processes that transform a fertilized egg into a multicellular organism. 4. Explain the molecular, biochemical, and cellular events that regulate the development of specialized cells, tissues, and organs during embryonic development.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Fertilization: Mechanism of fertilization, early and late changes in egg organization caused by fertilization, molecular events during fertilization. Mechanism of fertilization in Sea Urchin. Cleavage and Blastulation: Patterns of cleavage, determinate and indeterminate cleavage with examples, influence of yolk on cleavage, metabolic changes during cleavage, morulation and blastulation in frog, chick and rabbit, types of blastulae. Gastrulation: Fate maps, morphogenetic movements in frog, chick and rabbit, significance of Gastrulation, exogastrulation. Development and functions of the foetal membranes in chick and mammals.	**15**
Unit II	Organogenesis: Development of brain, eye and heart in chick Anterior and posterior regions development in *Drosophila melanogaster*. Role of polarity genes (hunchback, bicoid and nanos) in anterior and posterior regions. Organizer Concept: Embryonic induction, primary organiser and its morphological differentiation, origin of primary organizer, inductive interactions, nature of inductive signal (Possible mechanism of neural induction) competence. Basic introduction to β-catenin pathway, ingression, epiboly,	**15**

	delamination, involution and invegination. Regeneration and Metaplasia: Distribution of regenerative ability, polarity in regeneration, mechanism of regeneration of amphibian limb and lens, metaplasia, super-regeneration and heteromorphosis.	
Unit III	Metamorphosis: Kinds of metamorphosis, metamorphosis in Amphibians, Physiological and biochemical changes during metamorphosis, hormonal control of metamorphosis. Teratogenesis: Genetic and environmental Teratogenesis, phenocopies, developmental mechanisms of teratogenesis. Ageing: Theories of Ageing (Quantative Changes in Nucleic Acids, Changes in Information Content, Changes in Protection Regulatory Mechanisms, Free Radical Theory of Ageing), Ageing and Immunological Surveillance (Somatic Mutation Hypothesis, Function of Thymus, Immune Surveillance); Ageing of Connective Tissue; Mental Aspects of Ageing.	**15**
Practical		
	1. Study of the permanent slides of the chick embryos (whole mounts) and those showing the embryology of frog. 2. Study of eggs from collected / preserved material 3. Study of development of frog, chick through models/charts 4. Study of chick embryos from 16-18 hrs, 24-28 hrs 33-36 hrs, 42-72 hrs of development (Whole mount models, charts)	**30**

Recommended Readings

Textbooks

- Vertebrate Development: Maternal to Zygotic Control: 953 (Advances in Experimental Medicine and Biology)- Francisco Pelegri, Michael Danilchik

- An Introduction to Embryology – B. I. Balinsky
- Comparative Anatomy and Developmental Biology (Z-72)- Prof. R. L. Kotpal (Rastogi Publications)
- Developmental Biology- Scott F. Gilbert and Michael J. F. Barresi
- Developmental Biology- Scott F. Gilbert and Susan R. Singer
- Essential Developmental Biology - Jonathan M. W. Slack and Leslie Dale

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Avian Diversity and Behavior

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Avian Diversity and Behavior	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: IX** **Paper: DSE**
Subject: Zoology		

Course: DSE2	Course Title: Avian Diversity and Behavior	
Course Outcomes: After studying this course, the students will be able to: • Understand Birds Diversity of India • Understand Birds Diversity of Uttarakhand • Understand Threatened, Endemic and Migratory Birds • Understand Different behavioral and ecological aspects • Know about the status and distribution of avian fauna of various habitats • Gain knowledge to identify the different species of Birds • Photography knowledge • Bird watching ethics		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Introduction to Ornithology; Avian Diversity and Classification, Introduction to Birds: morphology, anatomy, food and feeding habits; Life History, Foraging Behaviour; Mating and Breeding Behaviour, Social Behaviour; Vocal Behaviour: Mechanisms; Ecology and Evolution; Vocal Behaviour: Case Study, Migration; Bird Populations, Concepts of Bird Communities, Mixed species flocks; Avian Disease. Body plan in birds: topography, feathers, avian flight,	**15**

	flight adaptation in birds.	
Unit II	Importance of birds, Breeding Biology, Territoriality, Nesting, Eggs, Incubation and case for the young, Brood parasitism. Birds Behaviour, Flying, Walking, Eating, Perching on trees or wires, Drinking water, Singing, Nesting, Preening, Moulting, Bathing, Dust bath, Flocking, Roosting etc, Understanding Camera basics and lenses and light conditions, Equipment for Bird Watching, Famous ornithologists of the World.	**15**
Unit III	Diversity and distribution of birds in India, notes on speciation in Indian birds. Endemism in Indian avifauna- endemic bird areas of India. Endangered and endemic birds of India and Uttarakhand. Status and distribution of birds in Uttarakhand. Major sites for migrant birds in India and Uttarakhand. Threats to migratory birds population sites in India and Uttarakhand. Flightless birds: status and distribution	**15**
Practical		
	1. Study of Bird Populations and Communities: Techniques 2. Case Study, Avian Conservation: Concepts; Case Studies 1 (House Sparrow Conservation Project); Avian Conservation Case Studies 2 (Asian Vultures Conservation Project). 3. Study of Photographing- water bird, Small perching birds, Birds in Dark Forest, Waders, Birds in urban setting etc. 4. Project Work and Field Report, field visits will be integral part of the Practical. Field trips for bird study, the trip will be day trips, three days camp for study of bird and their habitats, Visits to nearby Zoo, Museum, Forest, Nursery, Aquaria or any other relevant site must be	**30**

	arranged. The report of these visits will be submitted as part of the Practical work. Preparing of PPT, followed by student presentation. 5. Field visits to major sites for migrant birds – both wetlands and forests; field exercise in censusing and monitoring of migrant birds; analysis of eBird data on migration phenology of common migratory birds of India. 6. Group discussion/seminar on specific issues of bird conservation with case-studies from India and other Himalayan states.	

Recommended Readings

Textbooks

- Lovette I.J. and Fitzpatrick J.W. (2016). The Cornell Lab of Ornithology Handbook of Bird Biology (third edition). John Wiley and Sons, West Sussex, UK.
- Lovette, I.J and Fitzpatrick, J.W. 2016. Handbook of Bird Biology, 3rd ed. Wiley.
- .Gill, F.B, and Prum, R.O. 2019. Ornithology, 4th ed. Macmillan.
- Birkhead, T. 2013. Bird Sense: What it's like to be a bird? Bloomsbury, NY.
- Birkhead, T., Wimpenny, J., and Montgomerie, B. 2014. Ten Thousand Birds: Ornithology since Darwin. Princeton University Press, Princeton, NJ.
- Bhatt, Dinesh (Acoustic Communication in Birds).
- Ali, S. (2003). The Book of Indian Birds. Oxford Publishers. ISBN: 978-0195665239.
- Ali, S., Ripley, D. (1988). Handbook of the Birds of India and Pakistan: Together with Those of Bangladesh, Nepal, Bhutan and Sri Lanka. Oxford University Press, Bombay. 884pp. ISBN: 978-0195620634.
- Bibby, C.J., Burgess, N.D., Hill, D.A., Mustoe, S.H. (2000). Birds Census Techniques. 2nd ed. Academic Press, London. 180pp. ISBN: 978-0-12-095831-3.
- Bisht, A., Negi, B. (2022). Birds of Uttarakhand. Leafbird Foundation. 248pp. ISBN: 9788195630707.
- Grimmett, R., Inskipp, C., Inskipp, T. (2016). Birds of the Indian Sub-continent. 1st ed.. Bloomsbury

Publishers, India. 448 pp. ISBN: 978-8193315095.

- Singh, A.P. (2000). Birds of lower Garhwal Himalayas: Dehra Dun valley and neighbouring hills. Forktail: 101-124.
- Tong, W., Sheldon, B.C. (2020). Understanding Bird Behavior: An Illustrated Guide to What Birds Do and Why. Princeton University Press. 224pp. ISBN: 9780691206004.
- Ali, S. and Ripley, S. D. (1987). A Compact Handbook of the Birds of India and Pakistan, Second Edition. Oxford University Press, Delhi.
- Choudhury, A. U. (2000). The Birds of Assam. Guwahati Gibbon Books and World Wide Funds for Nature.
- Grimmett R, Inskipp C, Inskipp T. (2011). Birds of the Indian Subcontinent (2nd ED). Oxford University Press: United Kingdom.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Basic Limnology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE:Basic Limnology	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: IX** **Paper: DSE**

Subject: Zoology		
Course: DSE3	**Course Title: Basic Limnology**	
Course Outcomes: After studying this course, the students will be able to: 1. Get knowledge of relevance in limnology to analyze and evaluate abiotic and biotic conditions in aquatic systems. 2. Understand about the Inland Water bodies. 3. Understand the distribution and dynamics of plankton and benthos of freshwater bodies. 4. Knowledge of morphometry, physico-chemical and biological characteristics of fresh water bodies. 5. Understand the significance of aquatic flora, fauna, insects, birds and macrophytes in water bodies.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Introduction and Development of Limnology in India. Inland, Waters Distribution of Inland Waters: Ponds, Lakes, Streams, River. Lakes: Thermal Classification of Lakes, Famous Lakes of India and World, Nature of Inland Water Environment. Physical Characteristics: Pressure, Compressibility, Density Mobility, Buoyancy, Movement of Water Thermal Stratification Light, Color and Turbidity.	**15**

Unit II	Chemical Characteristics: Dissolved Gases – Oxygen, Carbon Dioxide and Other Dissolved Gases Dissolved Solids and Dissolved Organic Matter Influence of Physical and Chemical Conditions on Living Organisms in Inland Water Bodies. Planktonic Organisms: Classifications of Organisms in Water Distribution of Plankton Food For Plankton Organisms.	**15**
Unit III	Biological Productivity, Circulation of Food Material, Classification of Lakes Based on Productivity, Laws of Minimum, Biotic Potential and Environmental Resistance, Quantitative Relations in a Standing Crop Water Pollution, Eutrophication, Algal Blooms, Water Borne Diseases and Drinking Water Parameters Bioremediation of Polluted Water Bodies.	**15**
Practical		
	1. Determination of basic physico-chemical parameters of given water samples 2. Estimation of free CO_2 3. Determination of DO 4. Determination of pH 5. Determination of turbidity 6. Measurement of primary productivity 7. Qualitative and quantitative analysis of Phytoplankton 8. Qualitative and quantitative analysis of Zooplankton 9. Qualitative and quantitative analysis of benthos 10. Determination of total alkalinity 11. Determination of hardness	**30**
Recommended Readings **Textbooks**		

- Limnology- Alexander Horne and Charles Goldman
- Advances in Limnology – H. R. Singh
- Fresh Water Biology – W. T. Edmondosn
- An introduction to Limnology- Bhukya Sai kumar, Dharavath Ram Kumar
- Textbook of Limnology (PB 2015)- G. A. Cole
- Limnology Essentials: Ecosystems, Ecology and Evolution- Nishant Kumar Singh and amp; Murlidhar Rao
- Understanding Limnology- S. Srivastava

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Aquatic Diversity

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Aquatic Diversity	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: IX** **Paper: DSE**

Subject: Zoology		
Course: DSE3	**Course Title: Aquatic Diversity**	
Course Outcomes: After studying this course, the students will be able to: • Understand the different type of aquatic environment, importance of interaction of abiotic and biotic factors • Study the aquatic ecology and ecological modelling		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	History and Development of Limnology in India. Inland,Water Distribution of Inland waters Lentic and lotic water bodies Lakes: Thermal Classification of lakes, famous lakes of World, India and Uttarakhand. Physical characteristics: Radiant energy and optics, Density and thermal properties, Buoyancy, Compressibility, Thermal Stratification, Movement and suspended solids. Chemical Characteristics Dissolved gases- Oxygen, Carbon dioxide, pH and the hydrogen ion, Nitrogen, Phosphorus, Dissolved solids and dissolved organic	**15**

	matter. Influence of physical and chemical conditions on living organisms in inland water bodies.	
Unit II	Aquatic Ecosystem's structure and function: littoral Zone, limnetic zone,profundal zone, abiotic and biotic component, food chain, food web, trophic levels, ecological pyramids,primary and secondary productivity, movement of energy and materials, ecological efficiencies, thermal stratification circulation and lake typology. Limiting factors, Laws of limiting factor, Impact of temperature, moisture and pH on organisms. Structure and function of some Indian ecosystems Aquatic Freshwater marine andEstuarine) Planktonic organisms: Classification of organisms in water, distribution of plankton, food for planktonic organisms. Macrozoobenthos organisms: Classification of organisms in water, Distribution of zoobenthos, food for macroinvertebrates, water quality indicator organisms.	**15**
Unit III	Stressed water ecosystems: Point and non-point sources of pollution, assessment of freshwater pollution, assessment of freshwater using various parameters; water quality monitoring using abiotic factors (e.g. pH, Oxygen, Carbon dioxide, pH and the hydrogen ion concentration,Nitrogen, Phosphorus,BOD), Biomonitoring (phytoplankton, zooplankton andzoobenthos). Environmental Impact Assessment (EIA). Impact of environmental stress on biotic and abiotic factors. Water pollution, Eutrophication, algal blooms, water borne diseases, drinking water parameters,Bioremediation of polluted water bodies. National Lakes conservation program, Namami Gange Yojana,Sparsh Ganga Abhiyan.	**15**

Practical		
	1. Determination of D.O. content of water sample by Winkler method. 2. Estimation of the amount of free carbon dioxide in water sample. 3. Determination of salinity and chlorinity in water sample. 4. Determination of moisture content and total organic matter in soil sample. 5. Estimation of the alkalinity of water sample. 6. Quantitative study (total count and differential count) of planktons. 7. Calculation of similarity index between different communities. 8. Calculation of concentration of dominance for different communities. 9. Calculation of Shannon Weiner Index of diversity in different communities.	**30**

Recommended Readings

Textbooks

- Freshwater Biology - W.T Edmondson
- Methods for physical and chemical analysis of freshwater. - H.L Golterman,., R.S Clyno,. and M.A.M.Ohnstad,
- A Treatise on limnology. Vol. I and II John Wiley and sons- G.E. Hutchinson.
- Fish and Fisheries of India. - V.G. Jhingaran.
- Fundamentals of Ecology. - M Barrick, E. P Odum, G. W Barrett.
- Freshwater Ecology: Concepts and Environmental Applications of Limnology - W.K. Dodds and M.R. Whiles

Generic Elective (GE) – Computational Biology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Computational Biology	4	4	0	0	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: IX** **Paper: GE**
Subject: Zoology		
Course: GE1	**Course Title: Computational Biology**	
Course Outcomes: After studying this course, the students will be able to: 1. Understand the fundamentals of computer. 2. Use bioinformatics tools and databases to analyze DNA and protein sequences.		
Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Introduction to computers, Computer fundamentals (Hardware and Software),	**20**

	Input, Output devices and Storage devices, Web Browsers , Search Engines, Flow charts, Methods and types of networks, Intra and Internet, Introduction to MS-office.	
Unit II	Introduction to Bioinformatics, Scope and application of Bioinformatics, NCBI Data model, DNA and Protein Sequence database, Motif analysis, structural database, Structural Viewers (RasMol, RasTop, Cn3D, CSHF Chimera, Swiss PDB Viewer, PyMOL),	**20**
Unit III	Sequence submission to database, Literature database (PubMed, Biomed Central, Medline), Internet and biologist. Online study E.coli , D. melanogaster, Human genome, Mice genome. DNA Chips and their replications.	**20**

Recommended Readings

Textbooks

- Bioinformatics Methods- Shili Lin, Denise Scholtens
- Computational Biology- Er. H. Rocky Singh and Mohd. Azharul Haque
- Introduction to Computational Biology: An Evolutionary Approach - Haubold

Generic Elective (GE) – Medical Laboratory Technology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Medical	4	4	0	0	Passed Class XII with Biology	Nil

Laboratory Technology						

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: IX** **Paper: GE**
Subject: Zoology		
Course: GE2	**Course Title: Medical Laboratory Technology**	
Course Outcomes: After studying this course, the students will be able to: 1. Work under different specialties of Laboratory Medicine (Biochemistry, Microbiology, Pathology and Blood bank departments respectively). 2. Work and contribute in National Accreditation Board for Testing and Calibration Laboratories (NABL) program.		
Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Basic laboratory principles - Code of conduct of medical laboratory personnel. Organization and functioning of clinical laboratory. Safety measures - safety equipment's, safety symbols. Hazards in the laboratory (chemical hazards,	**20**

	clinical hazards, electrical hazards, biological hazards. Waste disposal.	
Unit II	Introduction of Common Laboratory Equipment's: Hot Air Oven, Incubator, Autoclave, Water Bath, Centrifuges. Microscope - Fundamentals of Microscopy, Resolution and Magnification, Light Microscopy, Electron Microscopy, PCR, Electrophoresis, UV trans illuminator etc. Specimen Collection, Processing and Analytical Techniques Collection and preservation of blood, urine, stool, sputum, pus, body fluids, swab. Preparation of blood smears. Sources of biological variations, pre-analytical variables.	**20**
Unit III	Preparation of reagents: Buffers and pH, Normal, percent and molar solution, normal saline –Methods of measuring liquids. Clinical Laboratory records - Modern Laboratory set up - Quality control: Accuracy, Precision, and Reference values. Disposal of biomedical waste laboratory safety protocols and guidelines.	**20**

Recommended Readings

Textbooks

- Textbook of Medical Laboratory Technology Clinical Laboratory Science and Molecular DiagnosisDarshan P. Godkar, Praful B. Godka
- Textbook of Medical Laboratory Technology- Mrinalini Sant
- Textbook of Medical Laboratory Technology- M. Sant
- Textbook of Medical Laboratory Technology- Ramnik Sood
- Medical Laboratory Technology, 4/e, Volume 2 Procedure Manual for Routine Diagnostic Tests Including Molecular Pathology- Kanai L. Mukherjee

SEMESTER- X
MASTER'S IN ZOOLOGY

DISCIPLINE SPECIFIC COURSE (DSC) – Applied Ichthyology / Biology of Insects (Morphology, Physiology and Development) / Animal Biotechnology (Transgenics, Cloning and IPR) / Applied Immunology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSC: Ichthyology - II A (Applied Ichthyology)	4	3	0	1	Passed Class XII with Biology	Nil
Entomology – II B (Biology of Insects)						
Animal Biotechnology- II C (Applied Animal Biotechnology)						
Immunology – II D (Applied Immunology)						

MASTER'S IN ZOOLOGY		
Programme: Master's in Zoology	**Year: V**	**Semester: X** **Paper: DSC**
Subject: Zoology		
Course: DSC	**Course Title: Ichthyology - II A (Applied Ichthyology)**	
Course Outcomes: After studying this course, the students will be able to: 1. Apply principles of phylogeny to understand fish adaptations.		

2. Become familiar with principals of ecology and behavior of fishes. 3. Become familiar with fish anatomy.		
Credits:4		**Discipline Specific Course**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Important cultivable fishes' Important cultivable shellfishes Biology of cultivated fish and shellfish. Fish preservation, transport and marketing. Ecology and productivity of fish ponds. Pollution in relation to fisheries. Carp culture: Mono culture, Poly culture and Composite fish culture. Live fish culture. Management practices: weed, insect, and carnivorous fishes.	**15**
Unit II	Maturation and fecundity, spawning and seed collection, Induced breeding, hatching techniques and hatcheries, nursery management, packing and transport of fish. Integrated Aquaculture: Fish-cum poultry, Fish-cum duckery, Fish-cum piggery, Paddy-cum fish culture and Dairy-cum fish culture.	**15**
Unit III	Induced spawning and hybridization. Factors responsive for induced breeding, hypophysation. Use of different synthetic and natural hormones. Larvivorus fishes and public health. Fish diseases and their management. Exotic fishes and their merits and demerits, Cryopreservation of gametes and embryos. Ornamental fish culture.	**15**
Practical		
	1. Determination of free CO_2 2. Determination of DO	**30**

	3. Determination of turbidity 4. Qualitative and quantitative analysis of phytoplankton 5. Qualitative and quantitative analysis of Zooplankton 6. Qualitative and quantitative analysis of benthos 7. Project Work and Field Report, field visits will be integral part of the Practical.	

Recommended Readings

Textbooks

- Textbook of Ichthyology- K. C. and Nirupama Agrawal Pandey
- Fish Physiology- William Stewart Hoar and David J. Randall
- Fishes: A Guide to Their Diversity- Philip A. Hastings, H. G. Greene, and Conrad Limbaugh
- An Introduction to the Study of Fishes- James S. Nelson, Terry C. Grande, and Mark V.H. Wilson
- General and Applied Ichthyology (Fish and Fisheries) – S. K. Gupta and P. C. Gupta
- Fish and Fisheries of India – V.G. Jhingran
- A textbook of Fish Biology and Fisheries – S.S. Khanna

Reference Book

- Applied Fishery Science. 1st ed. Jhingran VG, Pullin RSV. Delhi: Hindustan Publishing Corporation; 1985.
- Aquaculture and Fisheries Biotechnology: Genetic Approaches. 2nd ed. Dunham RA. Cambridge: CABI Publishing; 2011.
- Sustainable Aquaculture Techniques. 1st ed. Costa-Pierce BA. Boca Raton, FL: CRC Press; 2016.
- Advances in Fish Processing Technology. 1st ed. Hall GM. London: Springer; 1992.
- Post-Harvest Technology of Fish and Fish Products. 1st ed. Balachandran KK. New Delhi: Daya Publishing House; 2012.

OR		
Course: DSC	**Course Title: Entomology – II B (Biology of Insects)**	
Course Outcomes: After studying this course, the students will be able to: 1. Attain a solid foundation in insect biology, including general entomology, basic systematics, morphology, physiology, and biodiversity. 2. Understand evolution and biodiversity generation through macro- and micro-evolutionary processes, including how these processes have formed and diversified insects. 3. Develop the ability to design and perform a scientific study on insects, and to analyze results. 4. Develop an understanding of the distributions and abundances of organisms including insects, and their interactions with each other and the environment. 5. Develop an understanding of the distributions and abundances of organisms including insects, and their interactions with each other and the environment.		
Credits:4		**Discipline Specific Course**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Integument: Structure, functions and modifications of insect cuticle, moulting and sclerotization Structure of an insect head, thorax and abdomen; Appendages of head (mouthparts and antennae) and thorax (legs and wings) Structure of a wing of an insect, types of wings, hypothetical wing venation, wing-coupling mechanisms, and	**15**

	flight mechanism Structure and modifications of male and female genitalia in insects. Structure and modifications of alimentary canal; food and feeding mechanism of a generalized insect with special reference to physiology of digestion in different insects.	
Unit II	Structure and functions of blood and mode of circulation in insects' Principal organs of excretion of insects found in different habitats, physiology of excretion with special reference to osmoregulation in insects. Structure and functioning of various types of respiratory organs, modes of respiration, physiology of respiration in terrestrial, aquatic and endoparasitic insects Generalized plan of nervous system in insects and its modifications Neuroendocrine system in insects and the role of neurosecretion in various metabolic activities, metamorphosis and development of insects.	**15**
Unit III	Structure and functions of different types of visual and sound producing organs in insects. Structure, function and physiology of mechanoreceptors and chemo receptors in insects Bioluminescence: Light producing organs, mechanism and significance of light production in insect Structure of pheromone producing glands, different types of pheromones and their chemical nature Structure and modification of male and female reproductive systems in insects. Development: Structure of egg, maturation, cleavage, blastokinesis, formation of germ layers and segmentation; different types of larvae and pupae, Polyembryony and parthenogenesis in insects.	**15**
	Practical	
	1. Study the modifications of insect heads on the basis of their orientation (picture). 2. Identify different types of appendages of insect (slide). 3. To study mouth parts and their modification (slide).	**30**

	4. To study antennae and their modification (slide). 5. Study different types of legs (slide). 6. Study different types of wings (slide). 7. Study of wing venation and wing coupling mechanism in insects. 8. Study of alimentary canal/digestive system and nervous system of Cockroach and Grasshopper. 9. Determination of pH of the gut content of cockroach. 10. Study different type of larvae and pupae. 11. Study the stinging mechanism of honey bee. 12. To study the anatomical and physiological basis of sound and light producing organ in insects. 13. Project Work and Field Report, field visits will be integral part of the Practical.	

Recommended Readings

Recommended Text

- Introduction to General and Applied Entomology- V. B. Awasthi
- Entomology: An Introduction- George C. McGavin
- The Insects: An Outline of Entomology- P.J. Gullan and P.S. Cranston
- Insect Ecology: Behavior, Populations, and Communities- Peter W. Price
- The Insects Structure and Function – R.F. Chapman
- Imms' General Textbook of Entomology Volume 1 and 2 – O.W. Richard and R.G. Davies
- Applied Entomology – P.G. Fenemore

Reference Book

- General Entomology – M.S. Mani
- Insect Physiology and Biochemistry. 1st ed. Kerkut GA, Gilbert LI. Oxford: Pergamon Press; 1985.
- Developmental Biology of Insects. 1st ed. Counce SJ, Waddington CH. Cambridge: Cambridge University Press; 1972.
- Hormones, Brain and Behavior in Insects. 1st ed. Simpson SJ, Casas J. Oxford: Elsevier; 2011.
- Insect Molecular Biology and Biochemistry. 1st ed. Gilbert LI. London: Academic Press; 2011.
- The Development of Insect Form. 1st ed. Truman JW. Cambridge: Cambridge University Press; 1996.

OR

Course: DSC	**Course Title: Animal Biotechnology-II C (Applied Animal Biotechnology)**

Course Outcomes:

After studying this course, the students will be able to:

1. Play leading role in industry, research, and the public services.
2. Understand and appreciate major public concerns and issues associated with Animal Biotechnology.
3. Have an understanding and grasp of international research environment where the frontiers of knowledge in Animal Biotechnology are under research.
4. Be able to adapt and respond positively and flexibly to changing circumstances.
5. Develop the professional skills and personal attributes to deal with complex issues, both systematically and creatively.

Credits:4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks:**

		As per Univ. rules
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Animal Cell Culture: Equipment and materials for animal cell culture technology. Design and layout of culture room, Sterilization and aseptic techniques. Culture medium: natural media, synthetic media, sera. Introduction to balanced salt solutions and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium, role of carbon dioxide, serum and supplements in animal cell culture. Characteristics of cells in culture: Contact inhibition, anchorage dependence, cell-cell communication. Mechanical and enzymatic disaggregation of tissue and setting up of primary cultures, Candling of eggs, preparation of chick fibroblast, culture of lymphocytes for chromosomal studies. Roller and Suspension culture techniques.	**15**
Unit II	Large-scale production of cells using bioreactors, micro- carries and perfusion techniques. Measurement of viability and cytotoxicity. Biological characterization of the cultured cells, karyotyping, cryopreservation and revival. Detection of contaminants in cell cultures. Fermentation technology for the growth of animal cells and their products (Bioreactors, Hollow fiber reactors, Air-lift fermentors, chemostats and microarriers). Established cell line cultures: Definition of cell lines, maintenance and management; cell adaptation. Stem cell cultures, embryonic stem cells and their applications. Somatic cell genetics. Organ and histotypic cultures. Cell cloning, cell synchronization and cell manipulation.	**15**
Unit III	Various methods of separation of cell types, advantages and limitations; flow cytometry. Production and characterization of monoclonal antibodies and their application. Commercial applications of animal cell culture: cell culture based	**15**

	vaccines, Tissue culture as a screening system; cytotoxicity, in vitro testing of drugs and diagnostic tests. Mass production of biologically important compounds (e.g. Vaccines and Pharmaceutical proteins). Production of recombinant hemoglobin, blood substituents, artificial blood. Harvesting of products, purification, and assays. Three dimensional cultures and tissue engineering (artificial skin and artificial cartilage).	
Practical		
	1. Preparation of tissue culture medium and membrane filtration; 2. Preparation of single cell suspension from spleen and thymus; 3. Preparation serum; Egg candling; Cell counting and cell viability; 4. Chick fibroblast culture; Trypsinization of monolayer and sub-culturing; 5. Transfection of cultured monolayer; Cryopreservation and thawing; Measurement of doubling time; 6. Role of serum in cell culture; Preparation of metaphase chromosomes from cultured cells; 7. Isolation of DNA and demonstration of apoptosis of DNA laddering; Cell fusion with PEG; 8. Permanent slide preparation setting up and maintenance of fish hepatocytes /murine macrophages. 9. Project Work and Field Report, field visits will be integral part of the Practical.	**30**

Recommended Readings

Textbook

- Animal Cell Culture and Technology- Veer Bala Rastogi and Nirvika Rastogi
- Animal Cell Culture and Technology (The Basics (Garland Science))- Michael Butler

- Animal Biotechnology: Science-Based Concerns. 1st ed. Committee on Defining Science-Based Concerns Associated with Products of Animal Biotechnology. Washington, DC: National Academies Press; 2002.
- Transgenic Animal Technology: A Laboratory Handbook. 2nd ed. Pinkert CA. San Diego: Academic Press; 2002.
- Animal Cloning: The Science of Nuclear Transfer. 1st ed. Westhusin M, Betthauser J, Bishop M. Boca Raton, FL: CRC Press; 2002.

Reference Book

- Transgenic Animals: Generation and Use. 1st ed. Houdebine LM. Amsterdam: Harwood Academic Publishers; 1997.
- Principles of Cloning. 2nd ed. Cibelli JB, Wilmut I, Jaenisch R, Gurdon J, Lanza RP, West MD, et al. Amsterdam: Academic Press; 2013.
- Intellectual Property Rights in Agricultural Biotechnology. 1st ed. Singh RP. New Delhi: Daya Publishing House; 2014.
- The Science of Cloning: Genetic Engineering and Its Applications. 1st ed. Harris J. London: Routledge; 2004.
- Patent Law and Biotechnology. 1st ed. Kankanala C. Oxford: Oxford University Press; 2011.

OR

Course: DSC	**Course Title: Immunology – II D (Applied Immunology)**

Course Outcomes:

After studying this course, the students will be able to:

1. Understand the immune system: Students may learn about the components of the immune system, how cells and molecules work together, and how signal transduction pathways modulate the immune

response.

2. Apply knowledge: Students may learn how to evaluate how aberrations in immunoregulation can cause autoimmunity, immunodeficiency, allergies, and cancer. They may also learn how to apply immunology principles to develop new drugs, vaccines, and diagnostic techniques.
3. Learn how to communicate their views on the latest findings in written and oral formats.
4. Performing laboratory experiments: Students may learn how to perform common laboratory experiments, accurately record and analyze data, and present their findings in the context of scientific literature.
5. Critically interpreting data: Students may learn how to critically interpret published data relating to immunology research.

Credits:4	**Discipline Specific Course**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Immune response to infectious diseases: Mechanism of immune response during: viral infections [Influenza, HIV], bacterial infections [Corynebacteria, Mycobacterium] protozoan infection [Plasmodium, Trypanosoma and Leishmania], Helminthes infections [Ascaris, Schistosoma]. Disease of immune system and vaccines: Mechanism of autoimmune diseases- Systematic Lupus Erythromatous [SLE], Myasthia gravis, Rheumatoid arthritis, celiac disease. Cancer of blood cells- Lymphoma and Leukemia [Hodgkin and Non-Hodgkin]. Vaccines- historical background, routine vaccines, DNA vaccines, snake-antidotes. Production of monoclonal antibodies and its mechanism.	**15**

Unit II	Immuno-technology: Separation of immune cells by flow cytometry [FACS]: Its principle and application. Principle and application of immune-precipitation. Functioning and application of microscopes: Immuno-fluorescence and confocal. Principle and application of in-situ hybridization technology-FISH [Fluorescence In-Situ Hybridization] and GISH [Genome In-Situ Hybridization]. Principle, methodology and application of following techniques- ELISA [Enzyme Linked Immunosorbent Assay], RIA [Radio Immuno Assay], Western blotting. Allergy evaluation: Principle and methodology of skin prick test for allergy.	**15**
Unit III	Transplantation immunology: Transplantation- History, graft vs. host rejection studies for specific transplantation i.e skin graft, kidney, liver and heart with reference to hyperacute, acute and chronic rejection and its mechanism. Immunosuppression- definition, drugs used for Immunosuppression and its mechanism of action. Xenotransplantation- definition and its application. Graft vs. host reaction and diseases- definition, mechanism, treatment and prevention. HLA phenotyping, lymphoproliferation assay, its working principle and applications. Blood groups- MN, ABO blood group and blood transfusion.	**15**
	Practical	
	1. Preparation of Hyper Immune serum, its aliquots and serum heat inactivation. 2. Preservation and quality control measures of serum. 3. Immunoprecipitation test: single and double immune diffusion . 4. Haemagglutination assay. 5. ABO blood group analysis.	**30**

	6. Project Work and Field Report, field visits will be integral part of the Practical.	

Recommended Readings

Textboks

- Textbook of Fundamental Immunology- Dr. Varun Kumar Sharma
- Kuby Immunology- Judy Owen, Jenni Punt, Sharon Stranford, and Patricia Jones
- Basic Immunology: Functions and Disorders of the Immune System- Abul Abbas, Andrew H. Lichtman, and Shiv Pillai
- The Immune System- Peter Parham

Reference Book

- Vaccinology: An Essential Guide. 1st ed. Wraith DC, Goldman M. Oxford: Wiley-Blackwell; 2015.
- Immunotoxicology: Immune Dysfunction and Diseases. 1st ed. Kimber I, Salikoff M, Basketter D. Dordrecht: Springer; 2015.
- Allergy and Immunology. 1st ed. Mahmoudi M. New York: McGraw Hill; 2016.
- Tumor Immunology and Immunotherapy. 1st ed. Prendergast GC, Jaffee EM. New York: Academic Press; 2013.
- Immunotherapy in Transplantation: Principles and Practice. 1st ed. Kaplan B, Turka LA, Shaw LM. New York: Wiley-Blackwell; 2012.

DISCIPLINE SPECIFIC ELECTIVE (DSE) –Human Physiology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Human Physiology	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's in Zoology	**Year: V**	**Semester: X** **Paper: DSE**
Subject: Zoology		
Course: DSE1	**Course Title: Human Physiology**	

Course Outcomes:

After studying this course, the students will be able to:

1. Understand the mechanisms involved in digestion, respiration, blood, renal, and heart.
2. Understand the metabolism of carbohydrates, protein, lipids, and protein.
3. Understand the importance of macro- and micronutrients, and their deficiencies and effect on health.
4. Understand contemporary life-styles, parasitic microorganisms, and health.
5. Understand the anatomy of vertebrates, including their integumentary, circulatory, digestive, respiratory, urinogenital, and nervous systems.
6. Understand the sense organs in vertebrates.

Credits:4		Discipline Specific Elective
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Nutrition: Stimulation, secretion and action of digestive fluids (including enzymes and hormones). Digestion, absorption and assimilation of various food stuffs Human Digestive system - Digestion, absorption, energy balance, BMR. Sensory Physiology: Receptors, Pathways and physiology of smell and taste. Human Respiratory system - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.	**15**
Unit II	Blood and circulation in Human - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, hemoglobin, immunity, hemostasis. Cardiovascular System: structure of myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above. Human Nervous system - Neurons, action potential, gross neuro-anatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Nervous Coordination: Structure of neuron, nature, origin and propagation of nerve impulse, Synaptic transmission, Chemistry and functions of neurotransmitters. Sense organs - Vision, hearing and tactile response	**15**
Unit III	Excretory system - Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance. Muscle	**15**

	physiology: Structure, kinds and characteristics of muscles, Mechanism of muscle stimulation and contraction. Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. Temperature tolerance, Poikilothermic, Homoeothermic adaptations and regulatory mechanisms. Stress and adaptation. Excretion and osmoregulation: Functions of kidney, Types of nitrogenous wastes in different animal groups and their excretion, renal excretion in vertebrates (urine formation in a mammal in particular), osmoregulation in fish, reptiles, aves and mammals.	
Practical		
	1. Preparation of haemin crystals from human blood 2. Determination of clotting and bleeding time 3. Counting of RBCs in human blood; Counting of WBCs in human blood 4. Determination of haemoglobin percentage in human blood. 5. Recording of blood pressure 6. Examination of radial pulse 7. Electro cardiography; Clinical examination of cardio vascular system 8. Stethography for recording chest movements; Vital capacity; Artificial respiration – ALBP method demonstration 9. Clinical examination of respiratory system; Pregnancy diagnostic tests demonstration; Normal cardiogram of amphibian heart; Effect of	**30**

	temperature on cardiogram. 10.Case History/spotters/calculations	

Recommended Readings

Textbooks

- Essentials of Animal Physiology- S. C. Rastogi
- Animal Physiology and Biochemistry- R. A. Agarwal, Anil K. Srivastava,
- Principles of Animal Physiology - Moyes/Schulte
- Animal Physiology and Biochemistry- H. R. Singh and Neeraj Kumar
- Animal Physiology, Fourth Edition- Richard W. Hill, A. Gordon

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) –Osteology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Osteology	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's in Zoology	**Year: V**	**Semester: X** **Paper: DSE**

Subject: Zoology		
Course: DSE1	**Course Title: Osteology**	

Course Outcomes:

After studying this course, the students will be able to:

1. Understand Osteology of Bony fish (*Labeo*), Amphibia (Frog), Reptilia (*Varanus*), Aves (Fowl), Mammalia(Rabbit/Rat)

- Understand Vertebral column anatomy.

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	Topic	No. of Hours
Unit I	Definition of osteology; Introduction of Osteology; Cartilage: (Hyaline cartilage, elastic cartilage, fibrous cartilage, calcified cartilage); Bone: general characteristics of bone, types of bone (Cartilage bone, membrane or dermal bone); Anatomical Description: Acetabulum, Acrocoracoid, Acromian, Condyle, Coracoid, Deltoid ridge, Glenoid cavity, Ilium, Ilio-ischiatic fenestra, Ischium, Odontoid process, Olecranon process, Patella, Pubis, Scapula, Shaft, Sigmoid cavity, Sternum, Symphysis, Temporal arch, Zygomatic arch.	**15**

Unit II	Introduction of Skull; General characters of skull bone; Cranium: Occipital region, Parietal region, Frontal region, Ethmoidal region; Sense Capsule: Auditory capsule, Oribital capsule, Olfactory capsule; Visceral Skeleton: Mandibular arch, Hyoid arch, Branchial arches; Foramina and nerves; Dentition.	**15**
Unit III	Vertebral column anatomy: General characters of vertebra; Centrum; Cervical region (1- Atlas, 2- Axis, 3- Rest of the vertebrae), Thoracic region (vertebrae with ribs), Lumbar region (ribless vertebrae), Sacral region, Caudal region; Ribs and Sternum; Girdle.	**15**
Practical		
	1. Osteology of Bony fish (*Labeo*), Amphibia (Frog), Reptilia (*Varanus*), Aves (Fowl), Mammalia(Rabbit/Rat) 2. Jaw suspension in vertebrates. 3. Study of Different skulls of vertebrates.	**30**

Recommended Readings

Textbooks

- A Textbook of Comparative Osteology of Vertebrates by Deepak Rawal, LAMBERT academic Publishing.
- Comparative Study of Bones by Prof. S. C. Agarwal and Dr. J. C. Agarwal; Rajeeva Parkashan Meerut.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Biochemistry

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course	Eligibility criteria	Pre-requisite of the

		Lecture	Tutorial	Practical/Practice		**Course (if any)**
DSE: Biochemistry	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: X** **Paper: DSE**
Subject: Zoology		
Course: DSE2	**Course Title: Biochemistry**	
Course Outcomes: After studying this course, the students will be able to: 1. Understand the nature of biochemistry. 2. Understand the Physical and chemical properties of molecules as a linkage of biochemistry. 3. Understand the concept and properties of acid-base relationship.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**

Unit I	The molecular logic of life; Buffering in biological Systems; pH, pK, acids, bases, buffers, Handerson – Hassel Bach equation, weak bonds (Ionic, Hydrogen, Hydrophobic, Vander Waal interactions), covalent bonds, Water as a universal solvent. Molecular properties: Basic concept and significance of diffusion, Osmosis, Gibb's Donnan equilibrium, Viscosity, Surface tension and Colloidal state. Bioenergetics; Thermodynamic laws as applied to biological system, applications of free energy functions; High energy compounds with special reference to ATP. Biological oxidation-reduction reactions; Electron transport chain (ETS) and Oxidative Phosphorylation. Inhibitors of ETS and oxidative phosphorylation.	**15**
Unit II	Biomolecules; Chemical structure, classification and sources of biochemically significant carbohydrates. Chemical structure, classification and sources of biochemically significant lipids. Proteins – Amino acids and their classification, Peptide synthesis, Protein sequencing, Functional diversity, Structure and Conformation of proteins (protein structural hierarchy, Ramachandran plot, domains, motif and folds). Enzymes: Nomenclature and classification, kinetics, mechanism of enzyme action, factors influencing enzyme activity Isozymes. Coenzymes: Chemical structure and significance of coenzymes.	**15**
Unit III	Metabolism of carbohydrates: Steps, enzymes and inhibitors of glycolysis and TCA cycle, Glycogenesis, Glycogenolysis, gluconeogenesis, and the pentose phosphate pathway. Metabolism of proteins: Basic concept of protein metabolism with reference to decarboxylation, transamination, transmethylation and deamination of essential and non-essential amino acids. Glycosylation of proteins and glycosylation inhibitors. Biosynthesis of urea, creatine and heme. Metabolism of Lipids: Basic concepts of lipids metabolism with reference to biosynthesis and utilization of fatty acids of lipids. Significance of ketone bodies	**15**

	and cholesterol. Integration of metabolism and concept of metabolic regulations. General introduction to metabolic disorders. Vitamins: Chemical structure, sources and deficiency state of fat soluble and water-soluble vitamins. Minerals: Macro and micro nutrients. Sources and biochemical significance of minerals e.g. Sodium, Potassium, Calcium, Magnesium, Iron, Chloride, Zinc and Phosphorus and selenium. Basic concept of xenobiotic compounds and their metabolism. (Phase 1 and phase 2 reactions with examples).	
Practical		
	1. Qualitative identification of carbohydrate, protein and lipid. 2. Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose and starch). 3. Identification tests for Proteins (albumin and Casein). 4. Quantitative analysis of reducing sugars (DNSA method) and Proteins (Biuret method). 5. Qualitative analysis of urine for abnormal constituents. 6. Determination of blood creatinine. 7. Determination of blood sugar. 8. Determination of serum total cholesterol. 9. Preparation of buffer solution and measurement of pH. 10. Study of enzymatic hydrolysis of starch. 11. Determination of Salivary amylase activity.	**30**

Recommended Readings

Textbooks:

- Animal Physiology and Biochemistry- H. R. Singh and Neeraj Kumar
- Illustrated Biochemistry - Harper

- Biochemistry, -Satyanarayana
- Biochemistry and Molecular Biology Compendium- Roger L. Lundblad
- Textbook of Biochemistry for Medical Students- D. M. Vasudevan
- Text Book of Biochemistry- Dr. M. K. Gupta

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Metabolism of Biomolecules

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Metabolism of Biomolecules	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: X** **Paper: DSE**
Subject: Zoology		

Course: DSE2	Course Title: Metabolism of Biomolecules	
Course Outcomes: After studying this course, the students will be able to: 1. Understand the nature of biomolecules. 2. Understand the metabolic pathway of biomolecules. 3. Understand the concept biosynthesis of biomolecules.		
Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Glycolysis pathway, regulation and energy yield. Pasteur Effect and Crabtree effect, Fate of pyruvate - formation of lactate and ethanol. Citric acid cycle, regulation and energy yield Pentose Phosphate pathway,	**15**
Unit II	Gluconeogenesis, Glycogenolysis and glycogenesis. Diabetes Mellitus (elementary treatment) Diabetes ketoacidosis. Catabolism of lipids – β oxidation of fatty acids, energy yield. Ketogenesis, De novo synthesis of fatty acids. Biosynthesis of triacylglycerols and lecithin. Biosynthesis of cholesterol	**15**

Unit III	Biochemical nitrogen fixation, utilization of ammonia. Amino acid metabolism – deamination, decarboxylation, transamination. Inborn errors of aromatic and branched chain amino acid metabolism. (Phenylketonuria, Alkaptonuria, Albinism and Maple syrup urine disease). Biosynthesis and regulation of purine and pyrimidine nucleotides - de novo and salvage.	**15**
	Practical	
	1. Qualitative identification of carbohydrate, protein and lipid. 2. Qualitative tests of functional groups in carbohydrates, proteins and lipids. 3. Paper chromatography of amino acids; Action of salivary amylase under optimum conditions. 4. Effect of pH and temperature on the action of salivary amylase; Demonstration of protein separation by SDS-PAGE. 5. Qualitative identification of carbohydrate, protein and lipid.	**30**

Recommended Readings

Textbooks

- Harper's Biochemistry 23rd edition, 1993, Prentice-Hall International Inc.
- Lehninger Nelson, D.L. and Cox: Principles of Biochemistry (2013) 6th ed., M.M.W.H. Freeman and Company (New York).
- Lubert Stryer. Biochemistry, 1999, W. H. Freeman and Company, New York.

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Molecular Biology

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
DSE: Molecular Biology	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: X** **Paper: DSE**
Subject: Zoology		
Course: DSE3	**Course Title: Molecular Biology**	

Course Outcomes:

After studying this course, the students will be able to:

1. Understand the fundamental molecular mechanisms underlying cellular processes such as DNA replication, transcription, translation, and gene regulation.

2. Understand the proficiency in a variety of molecular techniques commonly used in research laboratories, including PCR (Polymerase Chain Reaction), gel electrophoresis, DNA sequencing, cloning, and recombinant DNA technology.
3. Analyze genetic data using bioinformatics tools and databases, enabling them to interpret DNA sequences, identify genes and regulatory elements, and analyze gene expression patterns.
4. Apply their knowledge of molecular biology to address scientific questions and solve real-world problems in fields such as medicine, agriculture, biotechnology, and environmental science.

Credits:4		**Discipline Specific Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Theory		
Unit	**Topic**	**No. of Hours**
Unit I	Introduction to Molecular Biology: Structure and organization of genome. Human genome project, Law of DNA constancy, Cot curve (cot curve), c-value paradox, DNA renaturation kinetics, Determination of Tm value. Chemistry of gene: Structure of nucleic acids (A, B, C and Z-DNAs, RL-model of Sasisekharan; supercoiling; genetic and non-genetic RNAs), Watson and Crick Model of DNA. DNA Topology. DNA as genetic material, DNA Replication - (evidence for semi conservative replication); Prokaryotic and eukaryotic DNA replication, Molecular Mechanisms of DNA replication, Enzymes and accessory Proteins involved in DNA replication. DNA damage and DNA repair (excision repair, mismatch repair and SOS repair), Genetic disease in humans. Recombination, Homologous	**15**

	Recombination, Holliday junction, FLP/FRT and Cre/Lox recombination, Rec. A proteins and recombinases. Fine structure of gene; organization of typical eukaryotic gene, Benzer's analysis of r-II locus by deletion and complementation mapping; General introduction to complexities of gene regulation in eukaryotes, Regulation of Gene expression in Prokaryotes and Eukaryotes: Operon concept (E. coli lac operon, trp operon, L-arabinose operon), DNA methylation, Heterochromatinization, Environmental regulation of gene expression.	
Unit II	Mutation: Chromosomal aberrations (Numerical and Structural), Gene mutation: different types of mutations, mutagens, Detection of sex linked lethal and visible mutations in Drosophila. Transcription- Prokaryotic and Eukaryotic transcription, RNA polymerase and types of RNA Polymerase in eukaryotes and prokaryotes, General and specific transcription factors, transcription signals, promoter sites, rho and sigma factor, Regulatory elements and mechanisms of transcription regulation, Transcriptional and post-transcriptional modification. Reverse transcriptase, RNA processing; Modifications in RNA: 5'-Cap formation, Transcription termination, 3'-end processing and polyadenylation, Splicing; Ribonucleoproteins, RNA editing, Nuclear export of mRNA and stability.	**15**
Unit III	Translation-Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co-and post-translational modifications of proteins. Genetic code: Properties, codon usage patterns and codon bias (Wobble Hypothesis), new genetic codes in mitochondria and ciliate protozoa. Nucleic acid sequencing- Introduction and landmarks in DNA sequencing, Maxam Gilbert method, Sanger's method, introduction to automated DNA sequence, Pyro sequencing, Nextgen sequencing, Whole genome sequencing. Antisense and Ribozyme Technology- Molecular	**15**

	mechanism of antisense molecules, Biochemistry of ribozyme; hammer- head, hairpin and other ribozymes, strategies for designing ribozymes, Applications of antisense and ribozyme technologies.	
	Practical	
	1. Isolation of genomic DNA 2. Purity determination and quantization of DNA; 3. Electrophoresis of Proteins; Electrophoresis of DNA - linear, circular and super coiled; 4. Southern blotting; Western-blotting; RFLP analysis; Isolation of RNA; Northern blotting; Nucleic acid hybridization. 5. Study of metaphase chromosomes from permanent slides; 6. Study of various stages of meiosis from permanent slides; 7. Extraction/Isolation of genomic DNA and RNA from mammalian blood; Restriction digestion of with restriction enzymes; 8. Agarose Gel Electrophoretic analysis of DNA, and RNA; 9. Cellular fractionation of functional mitochondria Isolation of mitochondria from mouse liver by differential centrifugation. 10. Identification of mitochondrial fraction by assay of marker enzyme; 11. Observation of DNA fragmentation in apoptotic cells and Principle of FACS.	**30**

Recommended Readings

Textbooks

- Molecular Biology- Anjali Priyadarshini and Prerna Pandey
- Molecular Biology of the Cell, 7th Edition- Bruce Alberts

- Molecular Biology-P.S. Verma and V.K. Agarwal
- Practical Techniques in Molecular Biotechnology- Bal Ram Singh and Raj Kumar
- Textbook of Molecular Biology- Sastry
- Textbook of Cell and Molecular Biology- Ajoy Paul

OR

DISCIPLINE SPECIFIC ELECTIVE (DSE) – Aquaculture

No. of Hours – 75

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	**Credits**	**Credit distribution of the Course**			**Eligibility criteria**	**Pre-requisite of the Course (if any)**
		Lecture	Tutorial	Practical/Practice		
DSE: Aquaculture	4	3	0	1	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: X** **Paper: DSE**
Subject: Zoology		
Course: DSE3	**Course Title: Aquaculture**	

Course Outcomes:

After studying this course, the students will be able to:

- Describe the Principles of Aquaculture
- Identify the Design Construction of pond
- Indicate the Biological characteristics of aquaculture species
- Acquire knowledge on measurement of growth and water and soil quality parameter

Credits:4	**Discipline Specific Elective**
Max. Marks: As per Univ. rules	**Min. Passing Marks: As per Univ. rules**

Theory

Unit	**Topic**	**No. of Hours**
Unit I	Aquaculture Systems And Methods: Scope and definition; origins and growth of aquaculture; biological and technological basis; Traditional, extensive, semi - intensive and intensive culture; monoculture, polyculture, composite culture, mixed culture, monosex culture; cage culture, pen culture, raft culture, race way culture, culture in circulatory systems; warm water and cold water aquaculture; sewage – fed fish culture, integrated fish farming. SELECTION OF SITES: Survey and location of suitable site – topography; soil characteristics; acid sulphate soils; water source; hydrometerological data.	**15**

Unit II	Aquaculture Engineering : Design and construction of pond, layout and design of aquaculture farm, construction, water intake system, drainage system; aeration and aerators; recent advances in aquaculture engineering; tips for better aquaculture practices; design and construction of hatcheries. HYDROLOGY OF PONDS : Types of ponds; sources of water – precipitation, direct run off, stream inflow, ground water inflow, regulated inflow; losses of water– evaporation, seepage, outflow, consumptive use, water budgets of embankment ponds; water budget of an excavated pond; water exchange.	**15**
Unit III	Selection Of Species: Biological characteristics of aquaculture species; economic and market considerations; seed resources, collection and transportation. 6. PRE STOCKING MANAGEMENT: Sun drying, ploughing / tilling, desilting, liming and fertilization, eradication of weed fishes. STOCKING: Acclimatization of seed and release; species combinations; stocking density; ratio.POST STOCKING MANAGEMENT : Water and soil quality parameters required for optimum production, control of aquatic weeds and aquatic insects, algal blooms; specific food consumption, food conversion ratio (FCR), protein efficiency ratio, true net protein utilization, apparent net protein utilization, biological value of protein.	**15**

	Practical	
	1. Preparation and of an aquarium in a laboratory study of aquarium fishes with Zoological and common names 2. Visit a local pond and collect the edible fresh water fishes and culture in an aquarium 3. Study of types and management of fish culture i.e.; breeding, hatching, nursery, rearing and stocking ponds in nearby place/with the help of charts/models 4. Estimation of organic matter of bottom soil 5. Visit to local fish seed production centre and local fish farms 6. Collection of pond, river or ditches water for the study of physico-chemical analysis of water 7. Collect a fresh water sample from the local fresh water habitat for the study of microscopic organisms like protozoans, Daphnia, coelenterates etc. for identification in laboratory	**30**

Recommended Readings

Textbooks

- Mathew Landau. 1995. Introduction to Aquaculture.
- Daya Publishing House, New Delhi. 2. Pillay, T. V. R. 1993.
- Aquaculture: Principles and Practices. Fishing News Books. Black Well Scientific Publications. MPEDA, 1991. Hand Book on Shrimp Farming, Kochi, India.

- Jhingran, V. G. 1982. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi.

Generic Elective (GE) – Hydro Ecology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Hydro Ecology	4	4	0	0	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: X** **Paper: GE**
Subject: Zoology		
Course: GE1	**Course Title: Hydro Ecology**	

Course Outcomes:

After studying this course, the students will be able to:

- Understand the Fundamentals of Hydroecology.
- Describe Aquatic Ecosystems and Their Components.

• Analyze Water Quality and Its Impact on Ecology.		
Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	History, scope and applications of Hydroecology. Movement, distribution and management of water on Earth. Water cycle, water resources and drainage basin sustainability, maintenance of minimum water flow. Global warming and its aggravations. Impacts of climate change on water sector and agriculture sector. Need for vulnerability assessment, approaches and tools of assessment. Adaptation to climate change by various Mitigation measures for climate change.	**20**
Unit II	Climate change and India; impacts, sectoral and regional vulnerability in India. Evaluation of model simulation over India. Evolution of emission trading and design features, trading mechanisms.	**20**
Unit III	Earth's climate, climate change, Drivers of climate change, change scenarios. Climate Change Policy Framework. Impacts of climate change, Climate variability and natural resources. United Nations Framework Convention on Climate Change (UNFCCC). Kyoto Protocol and the flexibility mechanisms.	**20**

Recommended Readings

Textbooks

- Biology of Fresh Waters – Peter S. Maitland
- Das and Saikia, Irrigation and Hydropower Engineering, PHI Learning Pvt Ltd.
- K.N Sharma, Water Power Engineering, Vikas Publishing House.

- A. Michael, Irrigation Theory and Practice-2Nd Edn, Vikas publishing house, 2009.
- S. K. Garg, Irrigation Engineering and Hydraulic Structures: Water Resources Engineering (Vol. II). Khanna
- Publisher, 2020.
- V.V.N. Murty, and T. Kei, Land and water development for agriculture in the Asia Pacific region. Science

  Publishers, Inc., 1996.

Generic Elective (GE) – Conservation Biology

No. of Hours – 60

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title	Credits	Credit distribution of the Course			Eligibility criteria	Pre-requisite of the Course (if any)
		Lecture	Tutorial	Practical/Practice		
GE: Conservation Biology	4	4	0	0	Passed Class XII with Biology	Nil

MASTER'S IN ZOOLOGY		
Programme: Master's In Zoology	**Year: V**	**Semester: X** **Paper: GE**
Subject: Zoology		
Course: GE1	**Course Title: Conservation Biology**	

Course Outcomes:

After studying this course, the students will be able to:

1. Learn how to identify species, habitats and life cycles of birds, fish, and mammals.
2. Apply conservation strategies to promote biodiversity and mitigate threats. They can also learn how to implement sustainable practices that balance conservation with human needs.
3. Learn how to monitor and survey wildlife.
4. Learn about the principles of wildlife ecology and how to understand wildlife habitats.

Credits:4		**Generic Elective**
Max. Marks: As per Univ. rules		**Min. Passing Marks: As per Univ. rules**
Unit	**Topic**	**No. of Hours**
Unit I	Introduction to Conservation Biology: Definition, scope, and importance of conservation biology. Levels of biodiversity: Genetic, species, and ecosystem diversity. Threats to biodiversity: Habitat loss, climate change, pollution, overexploitation, invasive species. Conservation approaches: In-situ and ex-situ conservation.	**20**
Unit II	Conservation Strategies and Policies. Protected areas: National parks, wildlife sanctuaries, biosphere reserves. Endangered and endemic species of India. Role of organizations: IUCN, WWF, UNEP, and national agencies. Wildlife Protection Act (1972), Biodiversity Act (2002), and other conservation laws in India. Institutions and Their Role in Conservation: Zoos, Natural History Museums, and Collections. Zoological Survey of India (ZSI) and its regional centers.	**20**
Unit III	Conservation Initiatives and Sustainable Development: Community participation	**20**

	in conservation: Ecotourism, biodiversity hotspots, sacred groves. Species recovery programs: Project Tiger, Project Elephant, Vulture Conservation. Sustainable development and conservation: Climate change mitigation, afforestation, sustainable agriculture. Role of biotechnology in conservation: Cryopreservation, cloning, seed banks, Bioremediation.	

Recommended Readings

Textbooks

- Wildlife Perceptions, Threats and Conservation – Cheryl Ward
- Fundamentals of Wildlife Management – Rajesh Gopal
- Wildlife Conservation: Challenges and Opportunities – Suresh Chandra Sharma
- Wildlife Conservation in India-1 Road to Nowhere – H .S. Pabla
- Forest, Water and Wildlife Management A Futuristic Approach- Dr. Ajay Kumar Singh
- Wildlife Management in Karnataka : A Forester's Perspective- Dipak Sarmah
- Ecology, Wildlife Conservation and Management- Tapashi Gupta
- Wildlife Conservation and Management - Dr. Reena Mathur.
- Textbook of Wildlife Management 3ED – S. K. Singh